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DEA OF THE NORTH PACIFIC AND ADJACENT WATERS

BY

WALTER KENRICK FISHER

Professor of Zoology and Director of the Hopkins Marine Station of Stanford University, California

PART 3. FORCIPULATA (Concluded)

FOR THE INCREASE AND DIFFUSION OF KNOWLEDGE AMONG MEN
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PART 3. FORCIPULATA (Concluded)

FOREWORD

Part 1 of this work, comprising the Phanerozonia and Spinulosa, was issued on June 30, 1911. Part 2, containing an account of the families Brisingidae, Zoroasteridae, and four subfamilies of the Asteriidae—the Pedicellasterinae, Labidiasterinae, Coscinasteriinae, and Pycnopodiinae—was published on June 23, 1928. The present and final installment completes the Forcipulata with a description of the Asteriinae.

As described in Part 1, the region covered by this monograph embraces the western coast of North America from the thirty-second parallel of latitude to Point Barrow on the Arctic Ocean, all of Bering Sea, the coast of Asia from East Cape to Saghalien, and the Kuril Islands. It thus includes all the waters north of a line drawn from the southern end of Saghalien to the southern boundary of the United States. It may be well to repeat that information concerning the fauna of the Sea of Okhotsk is still very meager, and that within the region outlined, nothing is known of the sea stars of the great depths of the mid north Pacific.

In addition to matter covering the north Pacific fauna there has been added a summary of the species of the Asteriinae, Notasteriinae, and Neomorphasterinae of the world. Inasmuch as no genus is known to be common to both Northern and Southern Hemispheres, this quasi revision can conveniently be divided into two sections, each covering a hemisphere. The list of species has been brought up to the end of 1928.

The photographic figures were made in the photographic laboratory of the United States National Museum. The drawings are by the writer.

The material for study is that which has been indicated in parts 1 and 2 (p. 1). In addition, a number of valuable specimens from the Okhotsk Sea and vicinity have been donated by Dr. A. Djakonov, of the Museum of the Academy of Sciences, U. R. S. S., Leningrad, including four of Brandt's original series of *Leptasterias ochotensis*. Doctor Djakonov has kindly sent me examples of two of his new species, namely *Leptasterias orientalis* and *Lepasterias fisheri*. Mr. G. A. Smith of the British Museum (Natural History) has photographed the skeleton of the types of Bell's *Calvasterias antipodum* and Sladen's *Calvasterias stolidota* and has supplied information concerning essential anatomical details, omitted by the describers.

From acknowledgments to many colleagues who have directly or indirectly aided my work it is to be hoped I have made no serious omissions in the introductory paragraphs to parts 1 and 2. It is a truism not too often repeated that no serious piece of scientific work can be completed without the cooperation of others.

In bringing this monograph to a close it is perhaps permitted one to indulge in the pleasant retrospect of personal contacts and to record the hearty cooperation of the staff of the United States National Museum which has been more formally alluded to in the foregoing parts. The late Dr. Richard Rathbun, then assistant secretary of the Smithsonian Institution, always evinced a lively interest in the progress of this report—an interest which has happily been continued by his successor, Dr. A. Wetmore. Nor should I forget, in matters taxonomic, the wise decisions of such experienced experts as Dr. Theodore Gill and Dr. Leonhard Stejneger; nor in matters of book making, the seasoned counsel of the editor, Dr. Marcus Benjamin, cheerfully tendered for over a score of years.

The retrospect, coming nearer home, inevitably focuses on the late Dr. Charles Henry Gilbert, long professor of Zoology at Stanford University. A scientist of unusual talents and a controlled and logical mind, he followed to the letter the Bairdian precept that what is worth doing is worth doing well. To him as professor, colleague, and friend, I owe much, as well as to our mutual professor, colleague, and friend, the venerable Dr. David Starr Jordan. But for their confidence the present monograph—and others—would have been the pleasant task of another.

SYSTEMATIC DISCUSSION OF THE FAUNA

Order FORCIPULATA Perrier[1]

Suborder ASTERIADINA Fisher[2]

Family ASTERIIDAE Gray[3]

Subfamily ASTERIINAE Verrill (emended)

Asteriinae VERRILL, Shallow-water Starfishes, 1914, p. 42.—FISHER, Ann. and Mag. Nat. Hist., ser. 9, vol. 12, 1923, p. 250; Bull. 76, pt. 2, 1928, p. 57.

Diagnosis.—Asteriidae with abactinal spines short, slender to stout, conical, tubercular-subglobose, variously granuliform, sharp to capitate, single or in groups (but not as a rule prominent, styliform, or acicular, and more or less spaced and isolated); abactinal plates in more or less definite longiseries or irregularly reticulate, sometimes abortive; actinal area sometimes broad, with upwards of five longiseries of plates, sometimes without any actinal plates; genital apertures dorsal, lateral, or ventral; adambulcral spines with or without clusters of pedicellariae.

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[1] Key to the orders of Asteroidea, see pt. 1, p. 16.

[2] Key to the suborders and families of Forcipulata, see pt. 1, p. 3.

[3] Key to the subfamiles of Asteriidae, see pt. 2, p. 56.

KEY TO THE GENERA OF ASTERIINAE, NOTASTERIINAE, AND NEOMORPHASTERINAE OF THE NORTHERN HEMISPHERE [4]

a^1. Adambulacral spines provided with clusters of straight, or of straight and crossed pedicellariae, or exceptionally with only single pedicellariae.[5]

b^1. Adambulacrals diplacanthid, or mixed diplacanthid and triplacanthid, or mixed diplacanthid and monacanthid.

c^1. Dorsolateral plates not arranged in fairly regular longiseries; abactinal skeleton an irregular net, with or without the carinals in an evident longiseries.

d^1. Gonads opening dorsally; species never carry eggs and young (so far as known).

e^1. A single series of actinal plates either spineless and more or less superficially invisible, or with a small single spine; a single series of actinal papular areas alternating with the actinal plates; furrow spine of alternate adambulacral plates more or less advanced into furrow; inferomarginal plates strictly actinal in position, the superomarginals defining ambitus; cross pedicellariae not unusually large. Type, *A. rubens* Linnaeus.------------------------------------*Asterias* Linnaeus.

e^2. Actinal plates in three to five prominent series (each plate bearing one or two stout spines), separated by series of papular areas; furrow spine of alternate adambulacral plates often somewhat advanced into furrow; inferomarginals usually not actinal but lateral in position; crossed pedicellariae not unusually large. Type, *A. troschelii* Stimpson.-------------------------------*Evasterias* Verrill.

e^3. No actinal plates; with unusually large, slender-jawed, crossed pedicellariae; abactinal skeleton weak; marginal plates strong with one prominent superomarginal and one still longer inferomarginal spine; adambulacral plates mostly diplacanthid, with sometimes numerous straight pedicellariae along furrow margin; some of these occasionally attached to base of furrow spines *but not usually*. Type, *Asteracanthion linckii* Müller and Troschel-----------------------*Urasterias** Verrill.

d^2. Gonads opening ventrally; many species known to carry eggs and young; abactinal skeleton more or less open, the dorsolateral plates usually irregular, but spines sometimes in poorly defined longiseries; spines usually small, normally with a small or fairly thick collar of pedicellariae; crossed pedicellariae without enlarged teeth on the moderately broad terminal lip; one, or in large species, two series of actinal plates; adambulacrals diplacanthid or mixed diplacanthid and monacanthid; adambulacral pedicellariae normally in clusters on the spines, but occurring singly and even very sparingly in individuals which have few pedicellariae elsewhere on body. Type, *Asteracanthion mülleri* Sars--------------------*Leptasterias* Verrill.

c^2. The dorsolateral plates have the appearance of being arranged in regular or subregular longiseries; in either case the carinals and marginals are always prominent and regular, and the dorsolateral small papular areas form longiseries.

d^1. Ambulacral pores not unusually large; gonads opening ventrally; adambulacrals diplacanthid or mixed diplacanthid and monacanthid. (Forms of *L. camtschatica*, *L. aequalis*, and *L. hexactis vancouveri*.)--------------------------*Leptasterias*, part.

d^2. Ambulacral pores unusually large (quadriserial); abactinal and marginal plates broad, lobed, closely imbricated, with very small papular areas; dorsolateral plates in three series proximally; plates closely covered with clusters of minute spinelets; two series of actinals proximally; adambulacrals mostly diplacanthid; gonads unknown. Type six-rayed. Type, *Leptasterias macropora* Verrill----------*Stenasterias* Verrill.

b^2. Adambulacral plates monacanthid; with actinal plates in one inconspicuous series or lacking and gonads opening ventrally (paedophoric); size small; pedicellariae on adambulacral spines rather few and inconspicuous. (Formae of several species.) --*Leptasterias*, part.

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[4] Genera not known from north Pacific marked with asterisk. For a key to genera of Southern Hemisphere see p. 217.

[5] The clusters of pedicellariae (both crossed and straight, or either in predominance, or either alone) are a characteristic feature of *Asterias*, ss., *Evasterias*, *Leptasterias*, and *Stenasterias*. Certain individuals of *Leptasterias* (as in *L. littoralis*) which vary in the direction of few pedicellariae, may almost or quite lack pedicellariae on the adambulacral spines (or in dried specimens lose the few they may have had). The character is fundamental and the few exceptions are individual or varietal rather than specific, *L. groenlandica* of the arctic Atlantic region usually lacks these pedicellariae; Bering Sea specimens have abundant adambulacral spine pedicellariae.

a^2. Adambulacral spines devoid of attached pedicellariae, although large and small straight pedicellariae may occur on the surface of the plates or on fleshy peduncles attached to plate near base of spines; clusters of the latter in dried specimens occasionally appear to spring from the spine sheath but in reality do not.

b^1. Abactinal skeleton an irregular net with meshes of various sizes, the plates being sometimes closely but irregularly imbricated by their lobes; abactinal plates not in rather obvious longitudinal series (but occasionally in more or less evident transverse series); carinal series usually but not always distinguishable and frequently very irregular.

c^1. Adambulacral plates diplacanthid, at least at base of ray; rarely triplacanthid and tetracanthid.

d^1. Crossed pedicellariae unusually large, the jaws narrow and rather definitely hooked terminally; dorsolateral skeleton a very delicate and irregular meshwork which may degenerate into more or less disconnected plates; marginal plates conspicuously larger than dorsolateral; carinal and dorsolateral spines acicular, isolated; actinals absent.

e^1. Crossed pedicellariae very large, and of unusual form, with slender, serrate jaws terminating in an unexpanded unguiculate tip; marginal spines prominent, acicular, one to a plate, the inferomarginals with a very large cluster or cushion and the superomarginals with a wreath of crossed pedicellariae; very numerous, large, compressed-ovoid straight pedicellariae; gonads opening just above superomarginal plates in interbrachial angle. Type, *Asteracanthion linckii* Müller and Troschel. *Urasterias** Verrill.

e^2. Crossed pedicellariae smaller with relatively stouter jaws, scattered thickly over the abactinal and lateral surfaces, *but not in wreaths or clusters* on the abactinal or marginal spines; superomarginals monacanthid; inferomarginals diplacanthid, or mixed monacanthid and diplacanthid distally; gonads opening just above superomarginal plates a short distance from base of ray. Type, *Asterias panopla* Stuxberg---*Icasterias** Fisher.

d^2. Crossed pedicellariae not unusually large, but small, with blunt, terminally spatulate, denticulate jaws—the conventional type.

e^1. No actinal plates; dorsolateral plates numerous, irregular, with small spinelets and showing sometimes a tendency to form transverse series (usually, however, not well marked); inferomarginal spines two to four in a transverse series, the consecutive combs closely placed. Inferomarginal spines bearing crossed pedicellariae; abactinal spinelets surrounded by a circlet of crossed pedicellariae.

f^1. Papulae compound, each subdivided terminally into upward of eight small papillae; inferomarginals diplacanthid, superomarginals monacanthid; adambulacrals diplacanthid; not fissiparous; gonads opening just above superomarginals abactinally in interbrachial angle; large unguiculate straight pedicellariae. Type, *Aphanasterias pycnopodia* Fisher----------------*Aphanasterias* Fisher.

f^2. Papulae simple, undivided; inferomarginals with three or four spinelets in a transverse comb; superomarginals with several spinelets in a comb; adambulacrals triplacanthid, at least in part; strongly fissiparous, rays upward of eight; gonads opening between supero and infero marginal plates, low on side of ray, in the axillary channel; large bivalved dentate straight pedicellariae. Type, *Asteracanthion albulus* Stimpson---------------------*Stephanasterias* Verrill.

f^3. Papulae simple, rays five, not fissiparous; gonads opening just above superomarginals at a distance from interbrachial angle; adambulacrals diplacanthid; inferomarginals and superomarginals with transverse comb of three or four spines each; straight pedicellariae small, compressed, lanceolate. Type, *Asterias japonica* Bell---*Aphelasterias* Fisher.

e^3. Actinal plates in two or three series (or equivalent). Resembling a *Henricia sanguinolenta;* plates small with numerous small granuliform, close-set spinelets; abactinal skeleton close-knit with small papular areas, rather irregularly distributed dorsolaterally but in definite marginal and actinal longiseries; carinal plates regular; superomarginals slightly broader than inferomarginals; crossed pedicellariae surrounding papular areas, not in circlets around spinelets; adambulacral plates with a transverse series of three or four spines proximally, usually three distally. Type, *Asterias rosea* Müller---------------*Stichastrella** Verrill.

c^2. Adambulacral plates monacanthid.

d^1. Actinal (ventrolateral) area broad with two to four longiseries of conspicuous spiny actinal plates; actinostome very sunken; adoral carina narrow and long; gonads opening dorsally; carinal plates evident; dorsolateral skeleton robust, irregular with stout spines; in addition to large unguiculate straight pedicellariae, a peculiar small straight variety having on each jaw a short, sharp, and a long, truncate, laminate prong; among the adambulacral spines are clusters of straight pedicellariae on long peduncles arising from the plates. Type, *Asterias ochracea* Brandt---- *Pisaster* Müller and Troschel.

d^2. No actinal plates, the diplacanthid inferomarginals adjoining the adambulacrals. Resembling *Tarsaster;* dorsolateral plates numerous, three or four lobed, forming a close reticulum on either side of the definite carinal series; spines short, cylindrical, blunt, mostly one on abactinal plates and two on inferomarginals; crossed pedicellariae scattered, not in circlets around spines; papular areas small in about three dorsolateral and one intermarginal series on each side; no actinal papulae; adoral carina composed of five pairs of contiguous adambulacrals; actinostome small, sunken; a few fairly large spatulate denticulate, straight pedicellariae; gonads opening dorsally. Type, *Hydrasterias verrilli* Fisher----------*Tarsastrocles* Fisher.

b^2. Abactinal plates, that is, the carinals and dorsolaterals, close-set, *in very regular longiseries.* Abactinal spinelets few, stout, granuliform.

c^1. Inferomarginal plates with an oblique series of three or four very flat, bladelike spines which form a prominent fringe along the edge of ray; above inferomarginals are five very regular longiseries of plates, the superomarginals broadest, strongly imbricated in series; whole abactinal surface, including superomarginals, has a granular appearance; five or six very short spinelets per plate; actinal plates small, one corresponding to each inferomarginal; adambulacrals diplacanthid; tube-feet quadriserial at base of ray. Type, *Gastraster margaritaceus* Perrier-------------------*Gastraster** Perrier.

c^2. Abactinals and marginals sparsely granulated, subhexagonal, imbricated in seven very regular longiseries; actinal plates with short spinelets, a second series present at base of ray only; primary apical plates enlarged, occupying all of the slightly sunken central portion of disk; adambulacrals diplancathid; resembling abactinally a short-rayed Zoroaster. Type, *Neomorphaster eustichus* Sladen------*Neomorphaster** Sladen.

Genus ASTERIAS Linnaeus, emended

Asterias Linnaeus, Syst. Nat., ed. 10, 1758, p. 661; ed. 12, 1766, p. 1098. Type, *A. rubens* Linnaeus.—Gray, Ann. Mag. Nat. Hist., 1840, p. 178; Synopsis, 1866, p. 1.—Perrier, Rév. Stell., 1875, p. 38.—Bell, Proc. Zool. Soc. London, 1881, p. 492.—Sladen, Challenger Asteroidea, 1889, p. 560.—Perrier, Exp. sci. Travailleur et Talisman, 1894, p. 108.—Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 12, 1923, p. 598.

Stellonia Nardo (part), Oken's Isis, 1834, p. 716. Type, *A. rubens*, first species, designated, Fisher, 1913.—Agassiz, Mém. soc. sci. nat. Neuchâtel, 1835, p. 191.

Uraster Agassiz (part), Mém. soc. sci. nat. Neuchatel, 1835, p. 191 (substitute name for *Stellonia*).—Forbes, Mem. Wern. Soc., 1839, vol. 8, p. 114.

Asteracanthion Müller and Troschel (part), Monatsber. Akad. Wiss. Berlin, 1840, p. 102; Archiv f. Naturgesch., 6 Jahrg., vol. 1, 1840, p. 320. Type, *Asterias rubens* Linnaeus.

Asteracanthium Brandt, Middendorff's Reise in den äussersten Norden und Osten Sibiriens, vol. 3, pt. 1, 1851, p. 28. Emended spelling for *Asteracanthion.*

Allasterias VERRILL, Amer. Journ. Sci., vol. 29, 1909, p. 65. Type, *A. rathbuni* Verrill; Shallow-water Starfishes, 1914, pp. 53, 188.

Parasterias VERRILL, Shallow-water Starfishes, 1914, pp. 53, 187. Type, *P. albertensis* Verrill.

Diagnosis.—Asteriinae having the adambulacral spines provided with clusters of pedicellariae, gonads opening dorsally, superomarginals defining ambitus, inferomarginals strictly actinal in position, and a single series of actinal plates, either spineless and more or less superficially invisible, or with a single spine. Abactinal skeleton an irregular net with meshes of various sizes, the plates being sometimes closely but irregularly imbricated by their lobes; carinal series usually distinguishable, often irregular. Adambulacrals diplacanthid or mixed diplacanthid and triplacanthid, or mixed diplacanthid and monacanthid; furrow spine of alternate plates more or less advanced into furrow; gonads large, eggs small; development indirect, through a free pelagic larva.

Asterias,[6] as here restricted, includes besides the well known type, *A. rubens*, *A. vulgaris* Verrill and *A. forbesi* (Desor) of the Atlantic coast of North America; *A. amurensis* of the North Pacific and western Arctic; *A. amurensis rollestoni* (Bell) and *A. versicolor* Sladen of Japanese waters.

The genus probably does not occur in the southern hemisphere, being there replaced by *Diplasterias* (*Podasterias*), some species of which closely resemble true Asterias.

Both *Allasterias* Verrill and *Parasterias* Verrill are straight synonyms of *Asterias*, sensu stricto.

ASTERIAS AMURENSIS Lütken

Plates 1–5; Plate 6, Figures 2–8, 10, 11; Plate 7

Asterias pectinata BRANDT(?), not Linnaeus, Prodromus, 1835, p. 270. Kamchatka.

Asterias amurensis LÜTKEN, Videnskab. Meddel. fra d. naturhist. Foren. Kjobenhavn, 1871, p. 296.—FISHER, Ann. Mag. Nat. Hist., ser. 9. vol. 12, p. 598.

Asterias rubens MURDOCH, Rep. Internat. Polar Exped., Point Barrow, 1885, p. 159.

Allasterias rathbuni VERRILL, Amer. Journ. Sci., vol. 28, 1909, p. 65, fig. 5; Shallow-water Starfishes, 1914, p. 189 ("Maloska" = Unalaska).

Allasterias rathbuni var. *nortonensis* VERRILL, Amer. Jour. Sci., vol. 28, 1909, p. 66, fig. 7 (Norton Sound).

Allasterias rathbuni var. *anomala* VERRILL, Amer. Jour. Sci., vol. 28, 1909, p. 66, fig. 5 (St. Michael, Norton Sound).

Allasterias rathbuni nortonensis VERRILL, Shallow-water Starfishes, 1914, p. 191, pl. 78, fig. 2, text figs. 8, 9.

Allasterias anomala VERRILL, Shallow-water Starfishes, 1914, p. 193, pl. 59, fig. 2; pl. 60, fig. 2; pl. 69, fig. 5; pl. 77, fig. 3; pl. 78, figs. 3, 4.

Parasterias albertensis VERRILL, Shallow-water Starfishes, 1914, p. 187, pl. 57, figs. 1, 2; pl. 70, fig. 6 (Albert Bay, British Columbia).

Asterias anomala A. H. CLARK, Rep. Canadian Arctic Exped., 1913–1918, vol. 8, 1920, p. 8*c*.

Asterias nortonensis A. H. CLARK, Rep. Canadian Arctic Exped., 1920, p. 8*c*.

The following is a translation of Doctor Lütken's original description:[7]

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[6] For a full summary of species see page 205.

[7] Made by Dr. Adam Bøving, of the U. S. National Museum, to whom I am greatly indebted.

Asterias amurensis

From the Okhotsk Sea and the coast of Amurland we have a quantity of large specimens of this starfish. It is very different from the one described by Brandt under the name of *Asteracanthion ochotensis;* this I have been able to determine through the kindness of the St. Petersburg Museum. The specimens from the Amur were collected by Captain Andrea.

All the available specimens (including the one in alcohol) have very broad and flat arms the dorsal and ventral side of which are separated by a rather sharp border. The madreporic plate is large and easily seen, and is located nearer the center than the angles between the arms. The dorsal side is rather densely beset with very short spines the position of which is without regular arrangement. They are placed singly, or two or three, sometimes four, together; along the mid line of the arms they come together in a wavy line that stands out clearly between the rest of the spinules, which are scattered and weak. The spinular covering is denser on the disk than on the arms. The individual spinules are conical or cylindro-conical, covered with asperities, and terminating in one, two, or three points. Between the reticulations of the skeleton there are numerous papulae; over the whole dorsal skin there are also a great many irregularly placed 2-bladed pedicellariae, both on the trabeculae of the skeleton and in the interstices; on the spines themselves I have never observed them. Along the lateral edges of the arms the spines are densely placed in a multiple series, and they also have a peculiar flat excavated and apically blunted form. After this dense series of marginal spines there follow on the ventral side first a zone which is nearly without spines, then a double (in large specimens triple or quadruple) series of similar but somewhat longer spines; then again a bare zone; and finally, near the tube feet, a dense double series (in large specimens it is apparently multiple) of slender, nearly cylindrical, somewhat flattened and excavated ambulacral spines. The 2-bladed pedicellariae which are placed between these three ventral spinous zones are noticeably larger than those of the dorsal side; but besides these a third form is present that is much smaller than those of the dorsal side, occurring in great quantities on the ambulacral spines, the marginal spines, and on the spinous zone between; they are especially present on the more or less excavated part of those spines which is turned away from the ambulacral groove; at the base of the ambulacral papillae there are furthermore to be observed quite a few large pedicellariae. The largest specimen before me has R=120 mm., r=35 mm.; the width of the arms at the base is 38 mm.

The following is Doctor Lükten's diagnosis:

Diagnosis.—Statura ampla. Branchia quinque lata, depressa, ancipita, acie acuta superficiem dorsalem a ventrali separante. Spinae dorsales disci densius, brachiorum sparsius despositae, singulae vel 2–4 juxtapositae, in media brachiorum parte saepe lineam continuam formantes, breves, conicae vel cylindroconicae, asperae, apice bifidae vel trifidae. Corpus madreporiforme spectabile, centro propior. Areae poriferae multiporae inter trabeculas sceleti calcarei. Pedicellariae minutae rectae compressae bidentes numerosae supra totam superficiem dorsalem sparsae, in spinis dorsalibus nullae. Ad margines laterales brachiorum spinae breves, planae, excavatae, obtusae, pluriseriatae, dense collocatae. In pagina ventrali zonae longitudinales binae nudae, spinis fere destitutae, cum serie spinarum similium sed paulo majorum duplici (in parte intima brachiorum saepe triplici vel quadruplici) alterant. Spinae ambulacrales graciles, cylindricae fere, mediocriter compressae, canaliculatae seriem duplicem formant vel multiplicem simulant. Pedicellariae dorsalibus conformes sed duplo majores zonas illas nudas maximo numero ornant, ad basin spinarum ambulacralium quoque crebre conspiciuntur; minutissimae, confertae, cruciformes latus cavam praecipue, pedibus averssum, spinarum ventralium, ambulacralium et marginalium frequentant.

Through the kindness of Dr. Th. Mortensen I have received a cotype, one of the original lot from the Amur country, and have made direct comparisons with numerous examples from Kamchatka and Alaska, as well as with specimens of *Asterias amurensis rollestoni* (Bell) from several localities in Japan.

The detailed description is based upon specimens from station 3242, 11 fathoms, Bristol Bay, Bering Sea. The cotype, figures of which are given, is closely similar to these, with the exception of having slightly smaller crossed pedicellariae.

It is obvious that *Asterias rubens*, *Asterias vulgaris*, and *Asterias amurensis* are very closely related and it is profitless to discuss whether they are distinct species or subspecies. There is no evidence of geographic intergradation between *rubens* and *amurensis*.

Diagnosis.—Differing from *A. rubens* Linnaeus in having, when adult, conspicuously broader rays, more numerous, usually shorter abactinal spinelets; 5 to 10 channeled or scoop-shaped superomarginal spines instead of two to five more or less terete, tapered, cylindrical, or clavate ones; in having a more nearly plane actinal surface (sharply defined by the rather thin edge of the ray, bearing a cheveux-de-frise of superomarginal spines), and by having a broader, flatter actinal interradial region; intermarginal spines frequently present. Rays constantly five; abactinal surface low-arched, resistant or flaccid; actinal surface nearly plane, with an unusually broad actinal area on proximal third of ray; rays broad at base tapering rapidly to a blunt point; interbrachia angular; adambulacral spines proximally usually three and two alternating; inferomarginal spines usually two. Large specimen, R 195 mm., r 53 mm., R=3.68 r; breadth of ray at base 65 to 67 mm., or one-third of r.

Description.—This species is very variable. While large specimens all have the same general appearance and are easily recognized, a detailed analysis of the structure will reveal considerable diversity in the size of the skeletal parts, especially of the dorsum, and in the number, robustness, and form of the spines. The breadth of the ray increases with age in such a way as to alter very materially the appearance of the animals. Quite immature specimens are therefore unlike the adults in general appearance. The following description is based upon a large specimen from station 3242, 11 fathoms, Bristol Bay. (Pl. 2, fig. 3; pl. 3, fig. 5.) Some of the variations exhibited by adults from southern Bering Sea are also noted. Under variations are listed the principal varieties which are present in a large series of specimens examined.

The Bristol Bay example measures: R 195 mm., r 53 mm., breadth of the ray at base, 65 to 67 mm., or about one-third R. The actinal surface is low arched, rather stout and resistant, and is beset with numerous uniform, small but robust spinelets 1 to 1.50 mm. long, outlining a very irregular and quite open mesh, containing many papulae, some of which are retracted, others inflated. The skin is pulpy and minutely wrinkled. A carinal series is scarcely discernible, though it is well marked in other specimens from the same haul by reason of the spines being much more closely placed. Laterally the spinelets tend to form longitudinal irregular series. The spinelets are about 0.75 mm. thick, often clavate, irregularly truncate with a groove or a shallow pit at the tip. The tip may be compressed and incipiently bifid. The groove may be simply a cleft in the side of the little pit or it may extend down the side of the spine which becomes a thick-walled half-tube. The distal spinelets are mostly without pits or channels. There is a good deal of variation, depending upon age and locality in the forms of the abactinal spinelets. They tend to become stouter and more gouge-shaped with age. In many small and medium-sized examples the spinelets are slender clavate or robust clavate, blunt or truncate, without any groove.

The superomarginal plates define the ambitus and their spines, which are about twice as long and two or three times heavier than the dorsolaterals, form a dense cheveux-de-frise on the very angular margin of the ray. There are six to eight divaricate, spatulate, gouge-shaped, round-tipped, spines to each plate of the proximal half of the ray [fewer distally and proximally in small specimens] and the clusters are close together. The channel is usually, but not invariably, on the upper or abactinal sides of the spine, and in small specimens the spines may not be channeled at all but simply clavate, and of varying degree of robustness.

Nearly midway between the ambitus and furrow margin is a double row of gouge-shaped spines separated from the superomarginals by a conspicuously broad intermarginal channel and from the adambulacrals by an actinal channel, both densely covered with papulae. While in this specimen there are only occasionally three inferomarginal spines, some examples, as, station 3243, have fairly regularly three on each plate of the proximal half of the ray, in addition to one or two short series of *intermarginal* spines (springing from intermarginal ossicles). The large specimen from station 3242 has no intermarginal spines but another from the same haul, with R 156 mm., has a series extending nearly half the length of ray, and spaced from these, toward the margin, a second row not so long. There are thus on the proximal third of ray four parallel series of spines, of which two are inferomarginal. The inferomarginal spines are untapered, or slightly broader at the tip than midway, or the reverse, and the depth of the channel, which is on the admarginal side, varies greatly in different examples, being absent in young. In the largest specimen the spines are 3 to 4 mm. long by 1 to 1.25 mm. broad. The first spine corresponds to the eleventh adambulacral plate. The marginal and abactinal spines are distally rough and minutely thorny.

The actinal channel is well marked but not so broad as the intermarginal. There are no actinal spines, but a single series of small actinal plates, largely obscured by the inferomarginals, is present.

The adambulacral spines are longer than the inferomarginal (about 5 mm.) and are so placed as to form three longitudinal rows along the margin of furrow. The spines of the innermost row are only on alternate plates, are set rather well into the furrow, on the furrow face of the plate, as in *Asterias rubens*, and are compressed, tapered, and bluntly pointed. This is followed by two slightly longer, often tapered, blunt spines (or by only one on the outer part of the ray) having a variably developed channel or groove down the outer side. The plates alternating with these have, proximally, two grooved subambulacral spines; distally only one. There are thus, proximally, three and two adambulacral spines alternating and distally two and one. Another large specimen from this station, already referred to, has two spines on both sorts of plates proximally and distally two and one, alternating. The grooves on the subambulacral spines becomes less and less well marked in progressively smaller specimens. It is normlly absent in small specimens even though well marked in large examples from the same locality. [The position of the furrow spine of alternate plates, near the morphological upper end of the adambulacral plate, led Professor Verrill to found the genus *Allasterias*. But the alternate furrow spines of *Asterias rubens*, the type of *Asterias*, have the same position.]

The mouth plates are sunken and bent down toward the actinostome, as is characteristic for the genus, but the oral angle although composed of upward of six pairs of contiguous adoral adambulacral plates, is not a thin carina as in *Orthasterias* and *Pisaster*, but broadens rapidly from the apex and is stout, and crowded with prominent spines. The mouth plates are small (but relatively larger in medium-sized and young examples) and the strongly arched sutural surface is turned toward the actinostome so that the chord or long axis of the surface is not horizontal but more nearly vertical, varying to about 45° in younger specimens. There are two spines on each plate—a slightly curved tapering blunt one at the inner end, directed over actinostome, and a straight tapering longer one, about the middle, and bent away from actinostome. The first adambulacral plate is conspicuously larger than the second, and the second than the third. In the largest specimen the first plate is actinally about three-fourths as long as the corresponding sutural dimension of the mouth plates; the second is three-fourths the first; the third, three-fourths the second, and the fourth, three-fourths the third; the fifth and succeeding plates about the same as the fourth. Viewed from the furrow face these plates resemble the stones of an arch, as the series is bent toward the actinostome at the inner ends. In small specimens this arching becomes less and less evident with decrease in size, and fewer plates are joined behind the mouth plates. The first and second adambulacrals, and sometimes the third also, carry but one spine. The first furrow spine may occur on the third plate or not until the seventh or eighth.

Abundant abactinal, intermarginal, and actinal papulae, the number increasing greatly with age.

Pedicellariae very abundant. Small ovate to lanceolate straight pedicellariae, much smaller than the spinelets, are scattered over the abactinal surface (largest in interradial depressions), on the superomarginal, intermarginal, and inferomarginal plates and the bases of the spines, and on the adambulacral and mouth plates and spines. There is a cluster of about 5 to 10 near the end of the furrow spines, and in addition to the more numerous crossed pedicellariae, also several near the end of the other adambulacral spines. Straight pedicellariae of the actinal surface are fully twice as large as the dorsal; of the former the intermarginal are probably the largest, though in some specimens the size increases slightly toward the furrow (but the adambulacral spinal pedicellariae are smaller). The number of pedicellariae varies greatly with age, and to some extent with locality.

Small crossed pedicellariae present on the abactinal and actinal surfaces, forming usually a single circle around the dorsal spines, and are distinguishable in dried specimens from the straight pedicellariae by their smaller size and blunt rounded tips. (The straight pedicellariae are found on the plates and among the papulae, and some of them are quite as small as the crossed.) The crossed pedicellariae, also, form clusters on the upper and outer sides of all the marginal and subambulacral spines, but not on the alternate *furrow* spines which carry only straight pedicellariae.

The pedicellariae are treated in some detail under Variations, where comparative measurements are given. The measurements of pedicellariae of a giant specimen would be somewhat misleading. See also, figures.

Madreporic body large, circular, nearly flat to decidedly convex, situated one-half r from center. It is 7 mm. in diameter and the fine striae radiate from the center.

Variations.—The breadth of the ray and width of intermarginal and actinal channels increases with age, as do, in general, the number of spines, pedicellariae, and papulae, the rigidity of the skeleton, and thickness of the spines. These changes operating together, or only in part as sometimes occurs, effect considerable differences in general appearance.

But in medium-sized and large examples that may reasonably be regarded as mature there are rather striking variations. The abactinal spines differ somewhat with practically every locality, and even at the same station exhibit minor differences not connected with age. They vary from fairly slender, slightly tapering, to stout, cylindrical, or clavate. The end may be merely blunt; or bifid or trifid; or swollen; or compressed a little and therefore sometimes spatulate, usually with a faint to decided groove. Such gouge-shaped spines predominate on the proximal part of the ray of some examples which have the spines of the distal half more generalized. Gouge-shaped spines are rare on immature examples, even though the adult has them well developed.

The stoutness of the abactinal ossicles and the relative size of the meshes of the skeleton are variable. The skeleton is sometimes quite flaccid, but this may be due partly to maceration in weak alcohol. In examples from shallow water both stout (station 3231) and relatively weak (station 3298) plates are found. The character of the bottom, and available food may affect this condition, but nothing is known concerning the cause of the difference. Usually the skeletons composed of weak plates carry the small terete, unmodified spines.

The marginal spines of shallow-water specimens seem to be at least slightly gouge-shape or grooved down the outer side in mature, large examples, but the stoutness of the spine, its form and the size of the groove varies greatly. In extreme cases the inferomarginal spines, which may be taken as an index, are rather slender, tapered, and only faintly grooved (Popoff Strait), while from the same locality another large specimen has spatulate conspicuously furrowed spines relatively two to three times as broad. From station 3231 (see p. 19) are examples of forma *anomala* having still stouter more scoop-shaped spines. There is every gradation between the extremes. In young, the marginal spines are always slender, and much more constant in form.

Certain specimens without reference to locality have one or two rows of *intermarginal* spines on the proximal part of the ray, the number of spines varying. Sometimes they have the appearance of completely filling the intermarginal channel proximally. This feature occurs in specimens from various parts of the range, for instance, southern Bering Sea, Norton Sound, Petropavlovsk, and in forms with both slender and very stout spines. It is present also in examples from deep water (81 fathoms, station 3257).

While most of the inferomarginal plates carry two spines in an oblique series, certain plates here and there have three in a triangular group. Frequently at the base of the ray there appears to be regularly three inferomarginal spines, but the outer is almost always an *intermarginal*.

The form of the subambulacral spines varies with that of the inferomarginals. When the latter are strongly sulcate, the subambulacrals are also more or less deeply grooved. This is well shown in examples from station 3231 (forma *anomala*), from other parts of Bristol Bay, Popoff Strait, Norton Sound, St. Michaels, and Petropavlovsk. The number of adambulacral spines is variable, two and three alternating, being the maximum. Often there are two on each plate or one and two alternating, with occasionally one and three. Even in large specimens the maximum number is found only at the base of the ray, one and two alternating being the rule on the distal part.

The number of abactinal crossed pedicellariae is variable, but for accurate comparison the character is too difficult to handle precisely. The size of the crossed pedicellariae is, however, useful. There is an increase in size from northern Japan to Bering Strait, while in eastern Bering Sea there is a further increase with depth. In shallow water a curious variety with heavier skeleton and spines (forma *anomala*) has larger pedicellariae than the typical form. A comparison of the sizes and details of pedicellariae is taken up in the following section, but the figures will give the best idea of the variations.

VARIATIONS OF SPECIMENS BY LOCALITY

1. *Amur* (*Gulf of Tartary*).—This is the cotype, collected by Captain Andrea. As I have but the one specimen, no notes can be given on the range of variation at the type locality; but there is no reason to expect that it is any less than at Petropavlovsk. Lütken, however, has described the types fairly completely, and I shall give a few figures of the spines and pedicellariae. R 115 mm.; rays flattened and distorted.

The abactinal spines give the impression, at first sight, of being mostly conical and pointed, but many of them are two or three pointed as Lütken writes. Such spines appear to have a notch or a pit at the tip, especially on the radial region; still others are frankly gouge-shaped at the tip. The abactinal crossed pedicellariae are few compared to the larger (but still small) straight pedicellariae, which are broadly lanceolate, acute, and about 0.375 mm. long. The abactinal crossed pedicellariae are about 0.23 or 0.24 mm. long. (Pl. 6, fig. 2.)

There are eight or nine gouge-shaped superomarginal spines, proximally, and two rows of intermarginal spines; inferomarginal spines two, broadly grooved or gouge-shaped; adambulacral spines usually two to a plate, the alternate plates with the characteristic furrow spine.

The actinal straight pedicellariae are broadly lanceolate, sharp and much larger than the dorsal (about 0.75 mm. long proximally on the intermarginal furrow).

Comparing the size of the actinal crossed pedicellariae of the cotype with comparable examples from Kamchatka, and of *rollestoni* from Japan, we have the following:

rollestoni (R 125 mm.), Hokkaido,[8] 0.17 to 0.23 mm. (Pl. 6, fig. 1.)
amurensis (R 115 mm.), Amur, 0.25 to 0.28 mm. (Pl. 6, fig. 2*a*.)
amurensis (R 130 mm.), Petropavlovsk, 0.3 to 0.36 mm. (Pl. 6, figs. 3, 3*a*.)

The actinal crossed pedicellariae of *A. amurensis rollestoni* are therefore about three-fifths the length of those of *A. amurensis amurensis* from Kamchatka. The cotype (Amur) is intermediate, but rather nearer to the northern specimens.

2. *Petropavlovsk, shore* (Pl. 1, fig. 3, pl. 3, figs. 2, 3).—There is a good series ranging from R 12 mm. to R 130 mm. (the last with r 35 mm., R = 3.7 r.). The

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[8] Specimens from Mororan on the south coast. Most of the pedicellariae are small, 0.18 to 0.21 mm., but rarely larger ones occur which measure 0.26 mm. These are very much in the minority, however. In Kamchatkan and Bering Sea examples occasional pedicellariae are found which are considerably larger than the average. Specimens of *rollestoni* from farther south on the east coast of Japan have actinal pedicellariae as large as 0.27 mm. and as small as 0.18 mm. In typical *rollestoni* the abactinal spines are fewer, stouter, and more widely spaced.

abactinal surface of large specimens is rather uniform in appearance. The dorsal spinelets are relatively small, a trifle shorter and slightly less numerous than in the cotype. They are rather more stubby and subclavate, but are, however, scoop-shaped in many cases or incipiently cleft at the tip; epidermis thick; straight pedicellariae rather few. There are six or seven superomarginal spines to a plate, usually one short intermarginal series, regularly two inferomarginal spines, and proximally two and three adambulacral spines, then two and two, and distally two and one. The ventral spines have the usual armature of pedicellariae.

The superomarginal and inferomarginal spines are robust and scoop-shaped, varying to a slenderer form, with or without a groove along the outer side. The marginal spines vary in stature from that characteristic of Verrill's "*nortonensis*" (yet Norton Sound examples may have thick spines) to the broadly spatulate scoop-shape form of forma *anomala*—medium slender to spatulate.

The subambulacral spines vary in size or robustness corresponding to the development of the marginal spines, and they usually have a well-marked groove down the outer side. A mature example, with R 89 mm. has, however, slender subambulacral and marginal spines without a groove or with only an indication near the tip. So far as form of spine is concerned, this series includes nearly the extremes of variation.

The pedicellariae are larger than in the cotype, yet not so large as in some examples from the eastern part of Bering Sea.

The details of the crossed pedicellariae, always somewhat variable, are pretty close to those of the cotype's pedicellariae. The straight pedicellariae, however, begin to show a tendency, much better marked in eastern Bering Sea specimens, to develop irregular spines at the tip of the jaws. (Pl. 7, fig. 1.) No two pedicellariae are exactly alike and a comparison of figures will give a better idea of the structure. In the cotype there is only the faintest suggestion of this. (Pl. 6, figs. 10, *a*, *b*, *c*.)

The larger straight pedicellariae of the actinal surface are about 0.75 mm. long, or sometimes somewhat larger. The crossed pedicellariae of the inferomarginal spines, in a specimen with R 130 mm., are 0.315 to 0.36 mm., while in one with R 89 mm., they measure 0.29 to 0.325 mm. The latter is a specimen with slenderer spines than the first and the pedicellariae are a shade less robust. (Compare pl. 6, figs. 3 and 3*a*.) These crossed pedicellariae, as noted in the preceding section, are larger than in the cotype.

The young, of course, have narrower rays and in very small examples (R 20 mm.) the intermarginal channel is *lateral* instead of ventral, while the ray is more nearly terete. This gives the creature an entirely different aspect. There are no actinal papulae, only one intermarginal papula to an area, and one or two abactinal to an area. Superomarginal spines two or one; inferomarginal two; adambulacral two, two or one, two.

3. *Port Clarence, Alaska, near Bering Strait.*—Two specimens. One has R 105 mm., r 25 mm., R=4.2 r.; breadth of ray at base 24 to 27 mm. The other has R 82 mm. In both specimens the abactinal spinelets are small as in the Petropavlovsk specimens, slightly more numerous, slightly tapered in some cases, blunt or incipiently grooved in the larger, and more often bluntly pointed in the smaller. The larger has

10 or 12 superomarginal spines to the plate proximally, while the smaller has about six. The larger has frequently three or four inferomarginal spines, and the intermarginal space of the proximal half of the ray is filled irregularly with similar grooved spines; the smaller has regularly two inferomarginal spines and a single regular very short series of intermarginals. The spines are stouter in the larger specimens. Both have the adambulacral spines 2–3 proximally, but in the larger the sequence is irregular; a very few plates have four spines. The abactinal crossed pedicellariae are not numerous and do not form complete circles around the spinelets. The actinal crossed pedicellariae are very closely similar in size and details to those from Kamchatkan specimens, as are also the straight pedicellariae.

In the larger specimen the carinal series of spines is not discernible at all; in the smaller it is well marked.

4. *Norton Sound, Alaska* (pl. 2, fig. 2; pl. 3, fig. 4).—There are five large specimens, no. 7621, from which the type of Verrill's *nortonensis* was selected. The largest measures R 120 mm., r 36 mm., R=3.3 r; breadth of ray at base variable, about equal to minor radius.

These specimens are quite comparable to those from Petropavlovsk, being characterized by small but variable abactinal spinelets, few abactinal crossed pedicellariae, but numerous small straight ones, six or seven stout, grooved, superomarginal spines, moderately slender to distinctly robust gouge-shaped inferomarginal spines, and slender ungrooved to stout, grooved subambulacral spines. There are usually two and three, or two and two adambulacral spines proximally, though the regularity is often broken.

Two large specimens of the same size differ in that one has nearly twice as many abactinal spines as the other. The example with the more numerous spines has them stouter, often broadened and gouge-shaped at the tip, and with fairly complete circumspinal wreaths of pedicellariae—about as numerous as in southern Bering Sea examples. The other one has more nearly cylindrical and bluntly pointed spinelets and perhaps half as many crossed pedicellariae.

In his description of *Allasterias rathbuni nortonensis* Verrill says that the type and only specimen seen "presents several rather strongly marked characters" but does not enumerate them beyond saying that "the characters that seem most important are the smaller size and the stouter form of the major straight pedicellariae. The dorsal and marginal spines are longer than in the typical form and the papulae are more numerous."

The straight pedicellariae (pl. 7, figs. 1, 1*a*) are not more robust than in specimens from other localities, there being variation in this regard. In an example with R 114 mm., the actinal straight pedicellariae are 0.75 to 0.85 mm., and hence pretty close to those of the cotype and of Kamchatkan specimens. The tips of the jaws are more elaborately spiny than in either of the above.

The crossed pedicellariae (pl. 4, fig. 4) are closely similar to those of the cotype, though larger. The abactinal are about 0.26 mm. long, and the actinal from 0.27 to 0.315.; hence they are nearly as in Petropavlovsk examples. The form is also closely similar, the jaws being of the stouter type that is found in some of the heavier spined Petropavlovsk specimens.

The subambulacral spines are slenderer than is usual, but are grooved at least on the distal part of the spine. (See Verrill, 1914, pl. 78, fig. 2.) Professor Verrill's type of *nortonensis* is an unusually slender-spined specimen; two of mine have somewhat stouter subambulacrals. These, as well as the inferomarginals, are stoutest in the large specimen with the fewest abactinal spinelets, noted above.

5. *Specimens from 50 fathoms or deeper.*—Stations 3225, 3257, 3310, 3311, 3334, 3335 (pl. 4, figs. 4, 5), 3538, 3539, 3547.

There are, altogether, 40 specimens from depths of 50 fathoms to 93 fathoms, taken north of Unimak and Unalaska, and from the vicinity of the Pribilof Islands. They are therefore from southern Bering Sea.

The largest specimen (station 3335, with R 145 mm., r 36 mm., R=4 r; pl. 4, figs. 4, 5) is fortunately from the greatest depth. It is comparable with large fully grown examples from shallow water in the same region, and there is surprisingly little difference, if the comparison is made with the slenderer spined specimens. The abactinal spinelets are smaller and a little more numerous. They are about the same as in the specimens from Petropavlovsk and northern Bering Sea. In form they are tapering and blunt or else the tip may be compressed. The superomarginal and inferomarginal spines are distinctly grooved, but the spines are often slightly tapered and of medium width. Occasionally the superomarginals are slightly spatulate. There is a single series of intermarginal spines extending about a third the length of the ray. The subambulacral spines are rather slender, tapered slightly, with a groove on the outer side. They are slenderer and relatively longer than in the Petropavlovsk examples, but are not different from specimens from station 3242, and other shallow water localities. There seems to be no constant difference between this large fully grown example from 93 fathoms and shallow water specimens.

In medium-sized and smallish specimens from deep water (as station 3257, 81 fathoms) the abactinal spinelets are so short that they are often no longer than the numerous pedicellariae, the abactinal surface appearing as if covered with a close rather uniform nap. In other specimens the pattern of the abactinal skeleton can be readily traced by reason of the stouter spinelets.

Specimens from intermediate depths show all sorts of variations, with the exception of the very heavy spatulate ventral spines. An example from station 3281, 36 fathoms, has coarse, well-spaced abactinal spines which are notched, pitted, and grooved as in shallow-water examples.

Specimens with the weakest, most flaccid abactinal skeleton are from station 3242, only 4.5 fathoms.

The crossed pedicellariae are surprisingly large. In a specimen from station 3225 (R about 115 mm.) the abactinal crossed pedicellarie of the abactinal surface range from 0.27 to 0.31 mm.; of superomarginal spines, 0.27 to 0.36 mm.; of the inferomarginal spines, 0.31 to 0.36 mm. (see pl. 6, fig. 7); of the subambulacral spines 0.36 to 0.38 mm. The actinal straight pedicellariae range from about 0.6 to 0.9 mm., the form being shown in Plate 7, Figures 10, 11*a*. The crossed pedicellariae are about as large as those of the heavily spined forma *anomala* and are larger than those of comparable shallow-water examples having typical spines. For instance, the inferomarginal crossed pedicellariae of the deep-water specimens are usually between 0.34 and 0.36 mm. (station 3225), while in a comparable example from station 3244, Bristol Bay, 4.5 fathoms, these pedicellariae are 0.25 to 0.315 mm.; in an example from station 3242, 11 fathoms, 0.27 to 0.315 mm.; in a specimen from 3248, 21 fathoms, a maximum of 0.315 mm.; Popoff Strait, Shumagin Islands, low water, 0.27 to 0.315 mm. These measurements are in agreement with those of crossed pedicellariae of comparable specimens from Petropavlovsk, Port Clarence, and Norton Sound. The larger *crossed* pedicellariae are therefore a characteristic of deep water specimens as they are of the thick-spined forma *anomala*.

Growth stages and young (pl. 5).—The change in form due to increase in size is shown by the following measurements of specimens from stations 3241 and 3242. The younger stages have both narrower rayed and broader rayed forms:

No.	1	2	3	4	5	6	7	8	9	10	11
Station	3241	3241	3241	3241	3241	3241	3241	3242	3242	3242	3242
R in mm	12	19	25	29	32	35	42	45	70	79	150
r in mm	3	4	6	6.5	9	7.5	10	12	20	22	45
R=r	4	4.75	4.16	4.46	3.55	4.6	4.2	3.75	3.5	3.59	3.3
Breath of ray in mm	3.5	5	7.5	6.5	10.5	10	12	14	21	27	52

The ratio between R and the breadth of the ray at the widest part, close to the base, varies from 3.4 : 1 in No. 1 to 2.8 : 1 in No. 11. No 5 is a broader rayed form, while 4 and 6 have relatively slenderer rays. In specimens of the size of No. 8, and larger, the proximal third of the ray increases more rapidly in width relatively than does the distal portion, so that the difference in appearance with increasing age is more marked than the figures seem to indicate. With the broadening of the ray at the base the intermarginal channel makes its appearance and quickly widens, leaving space also for an actinal channel. The presence of these regular channels is one of the characteristic features of this species, as of *rubens*.

In specimens as small as Nos. 1 and 2 the inferomarginal spines are lateral, with the superomarginal directly above them, the rays being subterete. They lack entirely the characteristic flattened appearance of the adult. In Nos. 5 and 6 the superomarginals are situated a little more laterally than the inferomarginals, while in No. 7 the inferomarginals are proximally frankly actinal in position, and the ray is acquiring the characteristic flattened appearance.

In No. 1 and other small examples the abactinal skeleton has relatively large meshes (naturally much fewer than in large examples) with one or two papulae to a mesh. The abactinal spinelets, 0.3 to 0.4 mm. long, are slender, slightly tapered, not close together and are tipped by several thornlets. Each mostly 3-lobed primary plate bears a spinelet, but the oblong or elliptical connecting plates are often spineless. In No. 1 there are no abactinal pedicellariae. These appear in No. 2.

In Nos. 1 and 2, the marginal plates are close together, one above another on the side of the ray, four lobed, and the lower or descending love of the superomarginal covers the dorsal lobe of the inferomarginal as in the various genera allied to *Coscinasterias*. There are one superomarginal and two inferomarginal spinelets and one to three forcipulate pedicellariae on them. The intermarginal papular areas are very small with a single papula to each. No actinal papulae in No. 1; a few make their appearance in No. 2, and in No. 3 the series extends half the length of the ray. In No. 3 the superomarginal spines have increased to two or three; in Nos. 5 and 6, three is the commonest number, occasionally four, while in No. 8, four or five are found.

No. 1 and No. 2 have proximally two, then alternately one and two, adambulacral spines, and while the plates upon which the later furrow spine will stand can be recognized, the spine itself is not yet differentiated from the others. This is very definitely beginning in No. 3, and the spines are well differentiated in No. 5. Adambulacral spinal pedicellariae appear first in No. 3.

The small specimens have no actinal plates. In Nos. 1 and 2 there is only one pair of adambulacral plates in contact behind the mouth plates; in Nos. 5 to 8 there are three, and in No. 10 there are five.

In No. 8 the superomarginal, inferomarginal, and subambulacral spines show the beginning of a definite shallow groove on the outer side, and the marginal spines are slightly broader toward their rounded tips. Considerably larger specimens, as for instance 9 and 10, may have narrower marginal spines; and the subambulacral spines are less evidently grooved—in fact the furrow shows faintly at the top only. The amount of grooving, after the animal reaches the age when it should appear, is not dependent upon size alone, but is subject to a very wide range of variation often in specimens from the same station, as in the case of the Petropavlovsk examples.

Anatomical notes.—Skeleton: As noted under description and variations there is considerable diversity in the stoutness of the skeleton—enough certainly to justify the assumption of more than one species if only a few isolated extremes were available. The skeleton is especially heavy in forma *anomala*.

The abactinal skeleton is the open irregular mesh type of *rubens*, with usually an irregular carinal series of plates forming a wavy line along the radius. The plates of the dorsolateral regions have generally three irregular lobes, or three sides, while the carinals start out in small specimens fairly regularly four lobed but become irregular with age. The 3-sided dorsolateral plates stand at the nodes of the net while the connecting bars are composed of one or two narrowly to broadly elliptical overlapping ossicles, some of which bear a single small spine. The primary plates usually bear a single spine, but some of them especially in the carinal series bear two or three. The breadth of the abactinal plates and the degree of overlapping determines the openness of the skeleton. The number of the meshes from one side of the ray to the other varies with age, and is difficult to count accurately—perhaps 12 to 14 is a fairly correct estimate for medium-sized specimens.

The superomarginal plates start out in young specimens in the normal 4-lobed form for the family but the dorsal lobe is later suppressed, while the ventral becomes less conspicuous as the plate lengthens, until a sort of lozenge form results. The plates are strongly imbricated with the adoral end outside. The inferomarginals are larger, more definitely four lobed, and are connected with the superomarginals by from one to three overlapping ossicles (except distally and in young specimens). One or even two series of these intermarginal ossicles may bear solitary spines proximally. (Normally the plates adjacent to inferomarginals bear a short series at base of ray.) The actinal plates are inconspicuous except near the mouth plates; there is a single incomplete series, which appears rather late, and they are spineless.

They have each, however, a long internal process which helps to support or strengthen the dorsal surface (Vide infra).

The most characteristic features of the internal skeleton are the extensive interbrachial septum; the series of accessory septa extending from the outer end of every second or third ambulacral ossicle to the border of the abactinal surface; and the comparative distinctness of the odontophore. The interbrachial septum is membranous with parallel dorsoventral columns of elongate, imbricated plates, the inner border being concave and strongly reinforced by plates, which are irregular and form a band much wider than the other columns. Between the dorsoventral columns there is, in small and medium-sized examples, an area of unfortified membrane, upon which the plates encroach more and more with advancing age.

The transverse, parallel septa which are found along the border of the ray are composed of long blunt processes which grow outward and upward obliquely from the inner surface of the actinal, inferomarginal, and intermarginal plates, the septum being continued dorsally and mesially as a membrance with a free concave mesial border. That part of the septum which joins the abactinal surface is strengthened by keellike extensions of the dorsolateral plates or their lower and outer ends. The condition of these septa, which are pretty evenly spaced, will depend upon age and the general "calcareousness" of the specimen. They extend to the end of the ray, becoming smaller as the ray attenuates, and are pretty regularly opposite alternate ambulacral plates. The ventral processes from the dorsolateral plates are a little more conspicuous in these distal septa.

The odontophore (pl. 4, fig. 6, O) is clearly outlined, in most specimens, from the pair of enlarged ambulacral ossicles which surround the first ampulla pore, whereas in *Orthasterias*, *Stylasterias*, and allies, it is hidden by tissue so that its contour is not evident. Its interradial dimension is about 0.45 of the extreme width.

The enlarged summit of the first ambulacral ossicle is separated from the companion by a broad muscular suture, oval in form, whose length equals that of the following seven or eight ambulacral plates.

The ambulacral ossicles are slender and long. The portion which forms the ambulacral ridge is especially compressed and thin, being only half the width of the intervening muscular sutures and therefore narrower than the corresponding part in *Orthasterias* and allied genera. The ambulacral pores are narrow (on the outside) with flaring sides. There are two rows on either side of the radial line and at the base of the ray the inner ends of the outer row interdigitate with the outer ends of the inner about one-third their length; far along ray about one-half. The first ampulla pore, on the inside, is of conspicuous size.

Internal anatomy.—The viscera do not present any differences from the typical *Asterias* arrangement. The gonads, of the racemose type, open dorsally on the interradial line at about the middle of r. The intestinal coecum is divided into two parts and each of these into about three lobulated subequal divisions, the longest not reaching the middle of r. The spacious stomach has strong retractors and the hepatic coeca are voluminous. The ampullae are obviously single, rather large, and there are conspicuous Tiedemann's glands, but no Polian Vesicles.

Forma ANOMALA (Verrill)

Plate 3, Figure 1; Plate 4, Figures 1–3; Plate 6, Figures 5, 6, 11; Plate 7, Figures 2, *2a–2d*, 4

Allasterias anomala Verrill, 1914.

Cape Lisburne, Arctic Ocean; St. Michael, Norton Sound; Bristol Bay (stations 3228, 3231, 3233, 3234). These specimens, 51 in number, are referable to Verrill's *Allasterias anomala*, the type of which, No. 3821, is one of a series of four dried specimens from St. Michael, of which I have three. These were collected November 1874, summer 1875, and August 5, 1876, by L. M. Turner. On page 67 (1914) Verrill states that the species is from Siberia, probably a lapsus.

Two of the St. Michael specimens, in poor condition, belong to forma *anomala*, while the third is forma *amurensis*. The dredged specimens, taken by the *Albatross*, are in fine condition.

Anomala differs from the type form in having much thicker and more spatulate scoop-shaped superomarginal and inferomarginal spines. The subambulacral spines are rather heavy, in extreme examples, frequently broadened at the tip, and very definitely grooved. The abactinal spines are short but thick, rather tubercular, and stouter than in the more generalized form. They are about 0.9 to 1.3 mm. long and about 0.7 to 0.8 mm. in broadest diameter, therefore often fully two-thirds as thick as high. But among the thicker spines there are other secondary slenderer ones. In form they run pretty much the whole gamut of shapes characteristic of the slenderer spined varieties—cylindrical, subclavate, round tipped, or even subcapitate; variously notched or sunken at the end, or without any specual modification; often scoop shaped. The skeleton is generally stouter than in the forma *amurensis*, and conspicuously heavier than in deep-water examples.

There is, however, a good deal of variation in the stoutness of the ventral spines. This is evident enough from a series of specimens from stations 3233 and 3234. Examples from stations 3304 (1), 3290 (1), 3244 (1), and 3247 (1) seem to be about intermediate between this variety and the stouter specimens of the usual Bristol Bay form, as described in detail. It is worth noting that in a considerable series, such as that from station 3233, some examples—extremes of the variety—exhibit a heavy rather rigid dorsal skeleton with fewer stubby spines, while a minority have a rather flaccid abactinal wall with much more numerous and delicate spines. The latter also have less spatulate ventral spines and are in fact quite intermediate with normal Bristol Bay specimens of that size (R about 90 mm.).

The crossed pedicellariae are larger than in the slender-spined forms from the same region (except those from deep water). Actinal pedicellariae (from specimens about 90 mm. major radius) range from 0.27 to 0.36 mm., the majority being over 0.32 while the abactinal crossed pedicellariae are around 0.26 and 0.27 mm. The minor details of the pedicellariae are of course variable, and the breadth is also slightly variable.

Professor Verrill (1914, pls. 59, 60, 69) has given good photographic figures of his type of *anomala*, and on Plate 78, Figure 3, a drawing of the ventral spinulation. His figures of the pedicellariae are so poor as to be misleading. On Plate 77, Figures 3, 3*a* (labeled *Allasterias forficulosa* by mistake in the explanation, p. 156), are shown crossed and straight pedicellariae, and on Plate 78, Figures 4, *a* to *e*, straight pedicellariae. The *crossed* pedicellaria, Plate 77, Figure 3*a*, is quite inaccurately drawn, as it is unlike any found in this form. The *straight* pedicellariae are also incorrectly drawn.

The two badly beach-worn examples from Cape Lisburne, Alaska, were picked up at the "coal station" after a northwest gale of four days, September 11 to 15, 1885, by Henry D. Woolfe. They constitute the only undoubted Arctic Ocean record and are notable for their thick, mostly cylindrical, round-tipped spines about 0.9 to 1 mm. long and 0.45 to 0.6 mm. thick. The marginal and ventral spines are also thick, and not particularly different from St. Michael or Bristol Bay specimens. The straight pedicellariae of the ventral surface (pl. 7, fig. 4) are, if anything, a little larger than in Bristol Bay examples, many reaching a length of 0.9 mm. (0.65 to 0.9 mm.). They are relatively narrower. The abactinal straight pedicellariae average 0.45 mm., sometimes smaller, and are about the shape of the ventral pedicellariae of the Bristol Bay specimen, station 3231. (Pl. 7, fig. 2.) The ventral *crossed* pedicellariae are about 0.315 to 0.35 mm. (some as small as 0.23 mm.) and are similar in detail to the abactinal, which are a trifle smaller (0.28 to 0.3 mm.). Figures of the Bristol Bay (pl. 6, figs. 5, 5*a*) and Cape Lisburne (pl. 6, fig. 6) specimens will bring out the slight differences.

Type.—In the University Zoological Museum, Copenhagen.

Type locality.—Amur country (northern part of Gulf of Tartary) eastern Asia.

Distribution.—Arctic Ocean, north of Bering Strait; Bering Sea; Okhotsk Sea, and the Asiatic coast south to northern Japan where the species intergrades with *rollestoni*. On the American coast the Shumagin Islands constitute the only certain record[9] south of the Alaskan Peninsula. Vertical distribution, low tide to 93 fathoms. Temperature records 32.2° to 45.5° F., the latter probably several degrees too high.

Specimens examined.—Eight hundred and sixteen.

Specimens of Asterias amurensis examined

Station	Locality	Depth	Nature of bottom	Bottom temperature	Number of specimens	Remarks
		Fathoms		° *F.*		
3225	North of Unimak Island, Aleutian Islands	85	Black stones	38.6	2	
3228	Bristol Bay, Alaska, 58° 39′ 20″ N., 157° 17′ 30″ W.	8	Gray stones and pebbles		1	*anomala.*
3231	58° 35′ N., 157° 28′ 50″ W	12	Stones		20	Do.
3233	58° 23′ 45″ N., 157° 42′ 45″ W	7.25	Sand, pebbles	44.5	13	Do.
3234	58° 27′ N., 157° 52′ W	5	Gray sand		3	Do.
3235	58° 16′ 30″ N., 158° 13′ W	11	Black sand		142	
3236	58° 11′ N., 158° 05′ 30″ W	14.75	Gravel, sand, shells	39	89	
3237	58° 08′ N., 158° 19′ W	19	Gray sand, gravel, shells		32	
3238	58° 03′ 40″ N., 158° 37′ 30″ W	18	Fine gray sand		15	2 bushels rejected.
3239	58° 22′ 20″ N., 159° 23′ 15″ W	11.5	do		4	
3240	58° 30′ N., 159° 35′ 50″ W	14.5	Fine black sand		8	
3241	58° 38′ 30″ N., 159° 33′ 30″ W	14	Black mud	38	28	1 peck rejected.
3242	58° 44′ 30″ N., 160° 08′ 45″ W	11	do		14	

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[9] The case of *Parasterias albertensis*, labeled as from British Columbia, is very perplexing. The species appears to be *Asterias amurensis*. There is a possibility that the specimen may have been transported by ship; or that it may have been picked up as a "curio" and labeled in good faith by the donor.

Specimens of Asterias amurensis examined—Continued

Station	Locality	Depth	Nature of bottom	Bottom temperature	Number of specimens	Remarks
		Fathoms		° *F.*		
3243	58° 45′ N., 160° 28′ W.	4.5	Fine gray sand		65	One-half bushel rejected.
3244	Mouth of Bristol Bay, 58° 37′ 20″ N., 161° 05′ W.	4.5	do		2	
3246	58° 26′ 30″ N., 161° 36′ W.	17.5	Gravel	38	8	1 bushel rejected.
3247	58° 40′ 45″ N., 162° 08′ 30″ W.	17	Pebbles, stones	40.6	1	
3248	58° 34′ 15″ N., 162° 22′ W.	21	Fine gray sand, gravel	43	16	
3249	58° 27′ 30″ N., 162° 36′ W.	13.5	Fine gray sand, broken shells	37	15	
3250	58° 11′ 30″ N., 163° 02′ 45″ W.	17.5	Gray sand	46.2	6	
3251	Bering Sea, 57° 35′ 50″ N., 164° 05′ W.	25.5	Fine gray sand	37.5	2	
3257	North coast of Unimak Island	81	Gray sand, gravel	39	14	
3259	do	41	do	40.6	27	About 100 rejected.
3260	do	13	Fine black sand	42	3	
3261	do	27	Black gravel, pebbles	41.2	2	
3264	do	40	Coarse sand, gravel	40.5	5	
3265	Northeast of Unimak	38	Black sand	39.8	8	
3266	do	24	do	42	5	
3267	do	32	do	41	7	
3271	do	25	do	41.9	13	
3272	do	31	Black and red sand	42	8	
3273	do	39	Gray sand, mud	38.5	5	
3274	North of end of Alaskan Peninsula; 55° 34′ 30″ N., 162° 31′ 45″ W.	19	Black sand, shells		1	
3278	do	47	Fine gray sand	38.8	1	
3281	do	36	Gray sand, black specks		1	
3285	do	35	do	41	3	
3286	North of Alaska Peninsula, mouth Bristol Bay.	37	Fine gray sand, shells, gravel	41.5	4	One-half bushel rejected.
3287	North of Alaska Peninsula, 56° 33′ N., 160° 14′ W.	30	Coarse black sand	42	43	1 peck rejected.
3288	North of Alaska Peninsula, 56° 26′ 30″ N., 160° W.	15	Black gravel	45.5	3	
3290	North of Alaska Peninsula, 56° 50′ 30″ N., 159° 01′ W.	16	Gray sand, gravel		14	2 bushels rejected.
3291	do	26	Black sand, gravel	41.2	21	
3292	do	32	do		8	One-half bushel rejected.
3293	Bristol Bay	30	Fine gray sand	40	3	Do.
3294	do	30	Black gravel	41	3	
3295	Bristol Bay, 57° 14′ 30″ N., 158° 26′ 30″ W.	11.5	Fine gray sand		3	Do.
3296	do	24	Gray sand, black specks	43	7	1 bushel rejected.
3297	do	26	Gray sand	41.5	5	
3298	do	20	Fine gray sand	43.8	14	1½ bushels rejected.
3299	do	20	Fine gray sand, yellow specks.	44	2	Do.
3300	Bristol Bay, 58° 12′ 30″ N., 159° 55′ W.	15	Pebbles	42.2	1	One-half bushel rejected.
3301	do	17	Fine gray sand		6	1 bushel rejected.
3302	do	30	do	40.2	2	One-half bushel rejected.
3303	do	33	Black sand	39.5	1	Do.
3304	Mouth of Bristol Bay, 58° 02′ 30″ N., 161° 13′ 45″ W.	28	Fine gray sand		6	
3306	do	33	do	38.9	1	Do.
3310	North coast Unalaska	58	Fine dark sand mud	41.5	2	
3311	do	85	Green mud	41	4	
3333	do	19	do	43.9	2	
3334	do	50	Mud, sand	42.6	5	
3335	do	93	Mud	40.8	4	
3508	Bering Sea, 58° 33′ N., 169° 49′ W.	23	Fine gray sand, shells	42	16	
3520	Bering Sea, 59° 28′ N., 170° 57′ W.	38	Green mud, fine sand	32.2	1	

Specimens of Asterias amurensis examined—Continued

Station	Locality	Depth	Nature of bottom	Bottom temperature	Number of specimens	Remarks
		Fathoms		° *F.*		
3538	Bering Sea, vicinity of Pribilof Islands	59	Green mud, sand	38	3	
3539	Bering Sea, east of Pribilof Islands	57	do	38. 9	1	
3547	Northeast of Unalaska	51	Fine black sand	45	1	
3777	Off Kamchatka	13	Sticky soft green mud		10	
	Norton Sound, 64° 12′ N., 162° 25′ W	17			1	No. 15809.
	Cape Lisburne, Alaska, Arctic Ocean				2	Henry D. Woolfe, *anomala*.
	Norton Sound	5			5	No. 7621, Murdoch.
	Kotzebue Sound ?				3	No. 10999.
	St. Michaels, Alaska				3	No. 2821, L. M Turner.
	Hagemeister Island, Bristol Bay				1	W. H. Dall.
	Iliuliuk Harbor, Unalaska	3–6	Stony		2	Do.
	Popoff Strait, Shumagin Islands	(1)			5	No. 3452.
	Unga Island, Shumagins				1	W. H. Dall.
	Petropavlovsk, Kamchatka				13	Albatross, 1906.
	Port Clarence, Alaska				2	Stanford University.
	Amur Province, Asia				1	Cotype, Copenhagen Museum.

[1] Low water.

Remarks.—The most conspicuous points of difference between *A. rubens* and *A. amurensis* have already been listed. I have examined specimens of *rubens* from Iceland, Faroe Islands, Dublin Bay, Ireland, Port Erin, Isle of Man, Farsund, Norway, and Kristineburg, west coast of Sweden. The species *A. rubens*, like *amurensis*, is extremely variable, and certain variations approach fairly close to *amurensis*. The general run of specimens, however, is rather easily distinguished. *A. rubens* resembles more nearly *A. amurensis rollestoni* of Japan, but I have never observed specimens of *rollestoni* as large as *rubens* grows to be.

It is to be noted that the furrow spine of alternate adambulacral plates is, in *rubens*, advanced into the furrow, as in *amurensis*. The genus *Allasterias*, for *A. rathbuni* (nearly typical *amurensis*) was based upon this character and consequently becomes a synonym of *Asterias*, ss.

Parasterias albertensis Verrill, 1914, is said to have been taken at Albert Bay, British Columbia (no. 5537, Yale Museum). I have examined the type which is a small *Asterias* having the characteristic arrangement of adambulacral spines and marginal plates. The specimen is small (R 54 mm.) and as is well shown by Verrill's figure (1914, pl. 57, fig. 1), the abactinal skeleton is rather irregularly reticulated, an irregular carinal series being clearly discernible. The abactinal spinelets are mostly one to a plate, short, slightly tapered, blunt with rough tips. Supermarginal spinelets, faintly capitate, proximally three, distally two, somewhat longer and stouter than abactinals; inferomarginals two, longer and slenderer, tapered; sometimes one or two isolated intermarginals. Adambulacrals on proximal part of ray alternately two and three spined; distally, diplacanthid. The triplacanthid plates have the inner spine set deeper in the furrow. Abactinal straight pedicellariae small, numerous, the larger about 1.5 the length of the crossed; actinal, large, numerous, similar to the slenderer sorts of typical *amurensis*.

If this specimen really came from British Columbia, which is somewhat doubtful, it is a form of *amurensis*. The southern-most record of *amurensis* is Popoff Straits, Shumagin Islands. It is rather odd that, in spite of all the collecting that has been done in Alaskan waters by the steamer *Albatross*, no specimens have been taken anywhere near British Columbia. Yet we have the curious case of *Leptasterias polaris katherinae* which is founded upon "chance" specimens.

Professor Verrill remarks that the "species looks more like the typical species of *Asterias* of the North Atlantic than any other west coast species known to me." This is partly due to the small size. The young of *amurensis* all have the narrower rays typical of *A. forbesi*, for instance.

Allasterias forficulosa Verrill[10] is a form of *Asterias amurensis rollestoni* Bell. Professor Verrill compares it with Alaskan specimens, but does not say wherein it differs from the common Japanese form. I have examined the type.

I have also examined the types of Sladen's *Astercanthion rubens* v. *migratum*[11] from the Straits of Korea. The largest has R only 17 mm., and is consequently too small to compare with adult specimens. It is likely a form of *amurensis*. *A. amurensis* might be expected to occur in the cold area of the Straits of Korea.

I have examined examples of Bell's *Asterias rollestoni* from Hokkaido (Hakodate and Mororan, on the southern coast); Aikawa, Rikuzen; Suruga Bay. While these specimens are variable, they agree in having somewhat narrower rays, more widely spaced abactinal spines, and especially in having smaller crossed pedicellariae. The inferomarginal pedicellariae of the Mororan example range in length from 0.17 to 0.23 mm., with a relatively few giants attaining 0.26 mm. In a comparable Kamchatkan specimen, with R 130 mm., the same pedicellariae measure 0.315 to 0.34 mm., with a minority attaining 0.36 mm. (Pl. 6 fig. 3*a*.) The type of *amurensis* is intermediate but nearer to the northern extreme. There is little doubt that perfect intergradation exists between *A. amurensis* and *A. amurensis rollestoni*.

Genus LEPTASTERIAS Verrill

Leptasterias Verrill, Proc. Boston Soc. Nat. Hist., vol. 10, 1866, p. 350. Type, *Asteracanthion mülleri* Sars; Shallow-water Starfishes, 1914, p. 116.—Sladen, Challenger Asteroidea, 1889, p. 563 (subgen.).—Perrier, Expéd. Travailleur et Talisman, 1894, p. 108.—Fisher, Ann. and Mag. Nat. Hist., ser. 9, vol. 12, 1923, p. 599.

Ctenasterias Verrill, Shallow-water Starfishes, 1914, p. 148. Type, *Asterias spitzbergensis* Danielssen and Koren (=*Leptasterias groenlandica* f. *cribraria*).

Diagnosis.—Asteriinae having adambulacral spine pedicellariae, as in *Asterias*, but differing in having gonads which open in the actinal interradial angle, usually on a low papilliform prominence, two to each interradius; eggs relatively few and large (much yolk); the small species known to brood eggs and young (in one case in the stomach); abactinal skeleton more or less open, the dorsolateral skeleton usually irregular, but the spines sometimes in poorly defined longiseries; spines usually small, normally with a small or fairly thick collar of pedicellariae; actinal plates in one or two series, sometimes feebly developed; adambulacral plates diplacanthid, or mixed diplacanthid and monacanthid, or exceptionally mostly monacanthid; adambulacral pedicellariae normally in clusters on the spines, occurring singly, or very sparingly in individuals which have very few; pedicellariae without enlarged teeth on the moderately broad terminal lip; straight pedicellariae variable—small to large—lanceolate to broadly ovoid, or even clam-shaped, edentate to unguiculate.

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[10] 1914, p. 194, type No. 1183, Mus. Comp. Zoöl., Japan.

[11] Journ. Linn. Soc., vol. 14, 1879, p. 432.

Subgenus LEPTASTERIAS Verrill

Leptasterias mülleri group; size small, symmetry pentamerous. North Atlantic, north Pacific, Arctic.

Includes the following species[12]: *arctica* (Murdoch), *austera* (Verrill), *fisheri* Djakonov, *groenlandica* (Lütken), *hylodes* Fisher, *hyperborea* (Danielssen and Koren), *leptalea* Verrill, *littoralis* (Stimpson), *mülleri* (Sars), *ochotensis* (Brandt), *orientalis* Djakonov, *tenera* Stimpson.

LEPTASTERIAS ARCTICA (Murdoch)

Plate 8, Figures 5, *5a–5h*; Plate 9; Plate 10; Figures 1–4; Plate 14–16

Asterias arctica MURDOCH, Report of the International Polar Expedition to Point Barrow, Alaska, under Lieutenant Ray, 1885, p. 159.—VON HOFSTEN, Die Echinodermen des Eisfjords, Küng. Svenska Vetenstapsakad. Handl., vol. 54, no. 2, 1915, p. 63.

Asterias nautarum BELL (nomen nudum), Sladen, Challenger Asteroidea 1889, p. 824 (nomen nudum). See FISHER, Ann. and Mag. Nat. Hist., ser. 9, vol. 18, 1926, p. 198.

Asterias mülleri LUDWIG, Fauna Arctica, vol. 1, 1900, p. 482.

Asterias hyperborea VERRILL, Amer. Nat., vol. 43, 1909, p. 553.

Leptasterias arctica VERRILL, Shallow-water Starfishes, 1914, p. 120, pl. 56, figs. 1, 2; pl. 71, figs. 1, 2; pl. 72, fig. 1; pl. 83, figs. 2, *2a*.—CLARK, Rep. Can. Arct. Exp., vol. 8, part C, 1920, p. 9c (Dolphin and Union Strait, Northwest Terr.)

This highly variable species is the equivalent of *L. mülleri* (Sars) to which it is closely related. Its status with reference to *mülleri* is the same as that of *Asterias amurensis* to *A. rubens*. In neither case is intergradation known, although very likely it occurs. *L. arctica* has two fairly well-marked formae. The northern or typical form is much less like *mülleri* than the larger Bering Sea race. It has been suggested[13] that *L. hyperborea* (Danielssen and Koren) is a high arctic form of *mülleri*. It is noteworthy that the arctic phase of *arctica* (forma *artica*) is not like *hyperborea*. If *L. arctica* intergrades with *mülleri* it does so by a series of forms which are less like *mülleri* than its own southern form, *beringensis*. *L. arctica* forma *arctica* stands geographically between *beringensis* and *mülleri*.

Diagnosis.—Forma *arctica:* Rays five; size small to medium. $R=4$ to $5+r$ in fully grown examples, or 3.5 r in small specimens. Largest of type series, R 36 mm., r 8 mm., $R=4.5$ r. Disk small, rays slightly swollen at base, gradually tapered to a blunt extremity. Rays well arched, with curved lateral face. Spines coarse, unequal in diameter abactinally, subcapitate, striate, surrounded by a wreath (often prominent) of crossed pedicellariae; carinal spines more crowded than the irregularly spaced but uncrowded dorsolaterals, usually somewhat larger, and arranged in a zigzag series distinguishable in the dried state at least. Superomarginal, inferomarginal and actinal series normally quite regular; sometimes a short intermarginal series of spines; adambulacral spines alternating irregularly one and two; unguiculate straight pedicellariae in the intermarginal and lateral channels and also sometimes abactinally and on proximal furrow spines.

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[12] Includes possibly *Asteracanthion mexicanum* Lütken (*Leptasterias mexicana*, Verrill, West Indian Starfishes, Bull. Stat Univ. Iowa, Nat. Hist. vol. 7, no. 1, 1915, p. 24). Too little is known of this form to venture an opinion. As Verrill says, it may be a young *Asterias*. In this work two other species are referred to *Leptasterias* by Verrill, namely, *Asterias fascicularis* Perrier which is a *Tarsaster* and *Leptasterias hartii* Rathbun, an *Allostichaster*.

[13] See von Hofsten, 1915, p. 62, for summary.

Description.—There are 42 specimens of Mr. Murdoch's type series from 13.5 fathoms 10 miles west of Point Franklin, Arctic Ocean (No. 7625 U.S.N.M.), ranging in size from R 4 mm. to R 36 mm. Forma *beringensis* attains R 73 mm., station 3442. The abactinal spines are coarse in relation to the size of the ray, not fine; not uniform in size; very distinctly spaced, not crowded. Neither are they regularly arranged in either transverse or longitudinal series. But there is a very distinct, irregular, even zigzag, radial row of larger spines in most of the specimens and a certain linear arrangement may be noted in the spinelets adjacent to the superomarginals. The spines are short and decidedly blunt; the larger, about as high as broad, are subcapitate, with evenly rounded or subtruncate, finely striated tips; the smaller are less capitate, cylindrical or slightly swollen with fewer striae and less regular tips. The spines are surrounded at mid height, or near the tips, by a wreath of crossed pedicellariae, the numbers of which are subject to individual and locality variation. They are more numerous in forma *beringensis*. In some alcoholic specimens the crowns of pedicellariae nearly or quite touch but not in the types.

The superomarginal spines are distinguishable by their regularity rather than by their slightly greater length. They are clavate, finely striated and relatively slenderer than the radial spines, as well as actually slightly longer. The series curves upward to the interradial angle and the intermarginal furrow is here a bit wider, and sometimes occupied by a short series of intermarginal spinelets which arise from the descending lobe of the plate. The character is variable. Rarely there is also a spine on the upper lobe of the plate, or a transverse series of three; station 3559. There are no intermarginal plates.

The inferomarginal spines are still longer, and a little stouter than the superomarginals, sometimes a little bent upward, subterete to clavate in form (in variants sometimes compressed, and much more robust than in the type variety). Both series have rough-tipped spines, and circumspinal wreaths of pedicellariae (or half-wreaths on the inferomarginals of small specimens). There is one short series of smaller, but similar, actinal spines. The length of the series varies with age; in the largest Point Franklin specimen it is half the length of furrow. In the largest examples the series reaches two-thirds to three-fourths the length of the ray.

The adambulacral spines are close-set, slender, terete, blunt, and stand one or two to a plate in irregular alternation. The proximal 8 or 10 plates are usually monacanthid, sporadically diplacanthid. About three post-oral adambulacral plates are in contact. These apparently always have but one spine each. The inner of the two adambulacral spines is generally slenderer and is bent over the furrow in some examples. It seems to be the only one which regularly carries straight pedicellariae (very variable in number, and absent in small specimens). Both spines have clusters of crossed pedicellariae. Some of these differ in detail from the abactinal crossed pedicellariae, as the jaw when viewed in profile possesses a longer terminal expanded lip, with more teeth. (See pl. 10, figs. 2, 2*a*, 3, 3*a*.) The pedicellaria is rather more tapered toward the end.

The mouth plates are small and carry three spines, the innermost quite small and at the inner *furrow* corner of the plate; the middle spinelet is a little longer and at the inner *suture* corner, but not so close to the actionostome; the third is 50 per cent longer and situated at about the middle of the actinal surface of plate. All bear broadly lanceolate straight pedicellariae similar to those on the furrow spines. In some large examples from other localities (as station 3543) the jaws may have two or three conspicuous teeth, as has the adambulacral and other straight pedicellariae.

The papular areas are small with one to four papulae on the rays, or occasionally slightly more. There is an intermarginal and one actinal series. (In the largest specimens the papulae are more numerous.)

Straight pedicellariae: More or less markedly unguiculate, slender, somewhat hand-shaped pedicellariae occur, in forma *arctica*, very sparingly on the abactinal surface, in the interbrachial channels, and in the intermarginal channels. (Pl. 9, fig. 8.) Just external to the adambulacral spines and on the oral and proximal furrow spines, there are usually a few but they are not so numerous as in forma *beringensis.* Ovate-lanceolate pedicellariae are common along the furrow face of the adambularcal plates. These have the tips of the jaws crossed, or one curved tip meets a notched tip. In southern Bering Sea specimens (forma *beringensis*) the unguiculate pedicellariae (pl. 9, figs. 10, 11) are sometimes fairly common abactinally, but not in forma *arctica.* The largest are in the axils of the rays, actinally, and in *beringensis* these may have as many as five teeth. (Station 3543, pl. 9, fig. 9.) While the dimensions vary a good deal, an axillary pedicellaria of a large specimen is 0.8 to 0.9 mm. long.

Crossed pedicellariae occur in wreaths around the abactinal and marginal, and as half wreaths on the actinal and adambulacral spines. In a specimen with R 36 mm., forma *arctica*, the abactinal are about 0.23 mm. long and the adambulacral 0.26 mm., most of the latter having a different shape from the former. (Pl. 8, figs. 5, *5a–5h*; pl. 10, figs. 1–3.)

Madreporic body small, but variable, about 0.6 r from center of disk, and with three to six spines on the adcentral margin.

Variations.—There are at least two recognizable intergrading formae.

Forma ARCTICA (Murdoch)

Plate 8, Figures 5, *5a–5d;* Plate 9, Figures 2, 7, 8; Plate 10, Figures 2, *2a;* Plate 14, Figures 1–4; Plate 15, Figure 1; Plate 16, Figure 1

The typical variety of this species, as indicated by the type series of specimens, is a fairly slender rayed, small sea star with rather coarse, unequal subcapitate abactinal spinelets, among which a very irregular radial series is discernible by reason of the greater size and usually more crowded arrangement of spines. In the type series the crossed pedicellariae are not very numerous on the abactinal spines, but this is a character which appears to vary with every station, and there are even considerable individual differences at the same station. Examples from 15 to 20 fathoms, Plover Bay, Siberia, and from East Cape, Siberia, are more plentifully supplied than are those from the American coast, and therefore resemble forma *beringensis.* But the crossed pedicellariae are more nearly like those of *arctica*, and the well-spaced dorsolateral spinelets are much smaller than the carinals and superomarginals. This may represent a ditinct forma ranging along the Arctic shores of Asia.

The straight pedicellariae are rather slenderer and have less well-developed teeth than have some of the stout spined *beringensis*. They are very scare abactinally in the type series; but in larger examples from Plover Bay and Cape Lisburne conspicuous straight pedicellariae of characteristic form are scattered here and there over the dorsal surface. They are slender, incipiently toothed, and as long as the secondary spines.

The largest Arctic specimen, from Cape Lisburne, has R 50 mm., and coarse well spaced, strongly capitate, striate, unequal dorsal spinelets.

The specimen from Nikolski, Bering Island, with R 39 mm., has heavy, capitate, subtruncate, abactinal spinelets and closely resembles the typical Arctic form. The marginal, actinal, and adambulacral spines are rather more robust than in any of the Point Franklin examples. (Pl. 14, fig. 4.) It is of interest to find that forma *arctica* extends so much farther south in the western part of Bering Sea than it does in the east. In the latter region it does not range south of latitude 60°.

Forma BERINGENSIS, new forma

Plate 8, Figures *5f–5h;* Plate 9, Figures 1, 3, 4–6, 9–12; Plate 10, Figures 1, 3, 4; Plate 14, Figures 5, 6; Plate 15, Figures 2–5; Plate 16, Figures 2–6

The bulk of the collection comes from the vicinity of the Pribilof Islands, from Bristol Bay, from off the north coast of the adjacent Alaskan peninsula, and of Unimak Island. Perhaps the most evident feature of these specimens is that they average much larger in size, although of course different growth stages are abundantly represented. Many of them have thick rays due usually to swollen gonads, although in specimens from the same dredge haul there is much difference in the thickness of the rays.

As a fair sample of the variations of specimens from the vicinity of the Pribilof Islands, 20 examples from station 3536, 40 fathoms, may be taken. Two specimens, each with R 58 mm., have r 11 and 12 mm., but the breadth of ray just beyond the base is 16 or 17 mm., and 19 mm., respectively. The swelling in the latter fairly extending toward the extremity. The abactinal spines are robust and have capitate, finely striated tips. There is much variation in the robustness and degree of spacing of the spines. In one variety the spines are fewer and widely spaced. Counting across the abactinal surface between the superomarginal series of either side, there may be only three series of major spines together with a few much smaller ones; or, on another ray of the same specimen, seven series. In a more normal, slender-rayed example of approximately the same size there are 10 or 12 spines across the base of the ray, but there is scarcely any arrangement in longiseries with the exception of the irregular carinals where the spines are usually distinguished by their slightly to decidedly larger size, and more crowded position. The sparsely-spined variety occurs at a number of stations, as, 3277, 3280, 3291, 3293, 3294, 3297, 3302, 3303, 3306, 3438, 3504, 3511.

The marginal and actinal spines are fairly typical and stand in regular series, generally only one to a plate, but there is considerable variation in the details of form, and the relative size of the supero and infero marginals. The latter are more variable *inter se* than the former. They are usually a trifle to decidedly larger than the superomarginals, varying from cylindrical to a subspatulate form, almost always swollen toward the tip, which is rounded or truncate, or slightly bent upward. The actinals are similar, but a little less heavy. The adambulacral spines ordinarily alternate one and two, and are terete, much slenderer than the actinals, and less variable as to form. The inner or furrow spine is slenderer than the outer, while the alternate single spine is about intermediate in size. One specimen, on the proximal half of ray, has two spines on nearly all the plates. The largest specimen in the collection, station 3442, with R 73 mm., has only one adambulacral spine to a plate. Crossed pedicellariae are very numerous.

The crossed pedicellariae are more numerous and larger than in the forma *arctica* (measuring about 0.27 mm. in length), but in this abundance there is considerable latitude. The abactinal spines, however, are provided with rather thick sheaths which usually reach nearly to the tip, and are there beset with one or, on the dorsolateral regions, two circles of pedicellariae, while the marginals may have three or four circles. On the inferomarginals there are often only half circles, and the actinals regularly have only half circles on the outer side. For different variations see Plate 14, Figures 1, 2; Plate 15, Figures 3 to 5; Plate 16, Figures 2 to 6.

Unguiculate straight pedicellariae are scattered rather sparingly over the abactinal surface but are fairly numerous and somewhat larger in the intermarginal and actinal channels, and in the interbrachial channel. Considerably smaller pedicellariae, with rather narrower jaws and smaller teeth are found sparingly on the proximal furrow spines. But 27 examples from station 3559, 39 fathoms, gray sand, vicinity of Pribilof Islands, while exhibiting individual variation, have these straight pedicellariae of the furrow spines much more numerously represented, even in small specimens. Straight pedicellariae are also more numerous on the body surface. The same is true of station 3543. (See pl. 9, figs. 9, 10, 11.) While the dimensions vary a good deal, an abactinal pedicellaria of a large specimen is about 0.9 mm. long, an axillary 1 mm., a suboral 0.6 mm., and a furrow 0.5 mm.

One of the specimens from station 3559 (pl. 15, fig. 1), intermediate with forma *arctica*, R 56 mm., is remarkable for having the superomarginal spines in a vertical arcuate series of generally three, or two on the distal third of the ray. The lowest spine stands on the descending lobe of the plate and would be classed as one of an intermarginal series which extends two-thirds or three-fourths the length of the ray. This gives a very spiny aspect to the lateral face of the robust ray. The spines of the radial region are coarse and abnormally crowded, the adambulacral spines are heavier than usual and clavate, truncate, while the crossed pedicellariae are unusually numerous. The other specimens have only a single superomarginal spine and are slender rayed.

Station 3294, Bristol Bay, 30 fathoms, black gravel, July 18, 1890.—The greater number of the 14 large specimens have the abactinal spines more widely spaced than is usual although the appearance is accentuated by the turgid rays (swollen by large gonads). The relatively few straight pedicellariae are slenderer and lack teeth as a rule. These, however, are present on pedicellariae from specimens taken at 3295, 11½ fathoms, fine gray sand, same general locality. The more sparsely spined examples from station 3302 (fine gray sand, 30 fathoms) also have toothed straight pedicellariae, but they are not very numerous. In fact the animals from the southernmost part of the range seem to be poorly provided with straight pedicellariae (except on the furrow face of the adambulacral plates) but there are exceptions to this, for a large specimen, with R 70 mm., and well spaced spines (five to seven across the dorsal area) from station 3277 (18 fathoms, gray sand and rocks, north of the end of the Alaskan Peninsula) has numerous dorsal, lateral, and actinal straight pedicellariae which either lack or have few short teeth. This specimen also has numerous furrow-spine straight pedicellariae, and the largest rays recorded for this species. Three other examples from the same station have much fewer pedicellariae and agree with the generality of material from the region.

One of the examples from station 3536 has six rays.

Aleutian Island form.—Specimens from the Aleutian and Shumagin Islands differ from typical *beringensis* in their smaller size, rather more terete and less obviously capitate dorsal spines. Straight pedicellariae are rather variable but in a specimen from Atka they are well developed with three or four curved teeth to each narrowly spatulate jaw. The largest specimens have R 35 mm. (Shumagin Island) and 36 mm. (Atka). As compared to forma *arctica,* for example, from Point Franklin, the Aleutian-Shumagin examples have more widely spaced, more uniform, and longer spines, with much more conspicuous wreaths of pedicellariae.

Young.—The young forecast some of the more salient variations of the adults and therefore differ among themselves, although less widely than do the mature examples. There is a good series of growth stages from the type locality, the smallest specimen having R 4 mm. In this there is a distinct lateral face to the ray formed by the phanerozoniate marginals (about eight) and the flat dorsal surface has only an irregular carinal series and a rudiment or two of the dorsolaterals. The dorsal plates bear one or two spinelets and a few crossed pedicellariae have appeared. The actinal plates have not yet appeared while the adambulacral plates are relatively more prominent than in larger specimens, with one or two rather slender clavate spines, relatively much longer than in the adult. A regular series of dorsalaterals next appears (R 7 mm.), while the crossed pedicellariae increase in number. There are none on the adambulacral spines which may be only one to a plate throughout the ray. The first straight pedicellariae have appeared in the furrow, but the larger type are found first in a specimen with R 9 mm. Here there are one or two in the interradial groove on the actinal surface where in adult life thay appear to guard the gonoduct apertures. In this specimen also the first adambulacral crossed pedicellariae occur on the proximal spines (in this specimen generally one to a plate). By the time R reaches 12 or 15 mm. the animal resembles the adult but the spines are slenderer, the pedicellariae much fewer, and the actinal plates either absent or rudimentary. Naturally also the plates and spines are less numerous than on the larger specimens.

Brooding habits.—Specimens from the following stations are carrying young:

Station 3240, Bristol Bay, June 8, 1890, temperature not recorded; one specimen.

Station 3241, Bristol Bay, June 8, 1890, bottom temperature, 38° F.; one specimen.

Station 3251, north coast of Unimak Island, June 14, 1890, bottom temperature 37.5° F.; three specimens.

Station 3255, north coast of Unimak Island, June 14, 1890, bottom temperature 37° F.; two specimens.

The crucial temperatures for the development of the embryo are therefore in the neighborhood of 37° and 38° F.

In size the specimens range from R 39 mm. to R 60 mm.

A brood pouch is formed by the strongly arched disk so that the basal portion of all five rays is brought together and the adjacent marginal spines interdigitate. The cavity thus formed is crammed with tiny sea stars which are attached to a common central mass by a long slender strand of tissue proceeding from the actinal interradial area just external to the mouth plates. This thread of tissue may be as long as the diameter of the sea star (2.5 mm.) or considerably longer. It enters the central mass which appears to consist largely of the twisted and tangled ends of these elongate larval organs. The surface of the mass shows numerous soft lobes, some of which appear to be the ends of larval organs, as one may tease the mass apart. It then shows a fibrous structure. There seemed to be about six or seven of these centers of attachment in the mass of tiny sea stars removed from a specimen from station 3251. In other words the mass was divisible into seven smaller clusters. The young were closely crowded into the temporary brood cavity, and were pressed closely against the actionstome. (Pl. 10, fig. 4.)

Anatomical notes, forma beringensis.—Skeleton: There are three quite regular series of plates on the ventro-lateral region of the ray, the superomarginals, inferomarginals, and actinals, graduated in size from larger to smaller in the order named. The superomarginals are prominently four lobed, the descending lobe overlapping the ascending lobe of the inferomarginals, which tend to suppress their ventral lobe as they are crowded by the similar actinal plates. There are fair-sized regular intermarginal papular areas, but the actinal series of papular areas may be suppressed in slender-rayed specimens; or in thick-rayed examples two incomplete series are present, the inner between the actinal and the adambulacral plates.

The carinal plates (pl. 9, figs. 1, 2, 3) with three to five short irregular lobes, are larger than all but a few dorsolateral plates and are crowded into an irregular zigzag series. The plates strongly overlap one another in the radial direction, without any intermediate ossicles, and laterally overlap the dorsolateral plates which in shape are irregularaly elongate or incipiently lobed and form a very irregularly meshed skeleton, as in *L. polaris katherinae*, *L. p. acervata*, and other species. A variable number of dorsolateral plates with three or four lobes, similar in form to the carinals are larger than the others, and are, like them, the most external of the skeleton. A maximum of three very irregular series can be traced on either side at the base of ray. The mesh is completed by smaller plates without lobes, or with less obvious ones. Different specimens vary in respect to the robustness of the dorsal skeleton. (Pl. 9, figs. 2, 3.) If the plates average slightly thicker, the aggregate result is smaller papular areas. The ambulacral ossicles are fairly large and typical of the genus, the two series of pores on either side being fairly close, since the channel is relatively narrow. Corresponding to the first 10 inferomarginals there are 28 or 29 adambulacral plates.

The actinostomial frame, composed of the combined first ambulacral ossicles plus the five interradial odontophores internally, and the five pairs of mouth plates externally, is stout and the actinostome is small—scarcely twice as broad as the suture length of the first ambulacral element. The latter is prominent and the radial suture is as long as the six succeeding plates measured on the radial line—a rather common proportion in the less specialized Asteriidae. The odontophore (the interradial plate to which the first ambulacrals, the orals, and the interbrachial septum are attached) is considerably broader than the interradial dimension. (Pl. 9, fig. 5.) The interbrachial septum consists of large irregular plates, sometimes completely filling the membranous septum, sometimes leaving irregular uncalcified spaces.

There are no lateral pockets of the coelom formed by keellike extensions of the inner surface of the actinal and marginal plates. The inferomarginals have rather long dorsal lobes, plane on the coelomic side, which underlie the descending lobe of the superomarginal; the actinals have a similar but shorter dorsal lobe. There is a rudimentary second series of actinal plates visible from the inside in large specimens, even when not evident externally.

Internal anatomy.—The gonads when mature are large, the testes being larger than the ovaries, and sometimes reaching nearly to the end of the ray. The ovaries, from the very limited number of examples examined, appear to be more compact, shorter, with a few divisions, the surface irregular from many lobules. The testes consist of a long central axis, giving rise on the outer side to numerous short compact very irregular lobes and on the inner or ambulacral side to six or eight long slender subdivisions which are provided also with irregular lobules. The gonads are attached to the wall of the ray on the inner side of a superomarginal plate, or just below it, and exactly opposite the interbrachial angle. The short slender gonoduct turns downward and passes outward very close to the interradial line, between the ascending lobes of the first two inferomarginal plates. In a large specimen from station 3442, August 3, 1891, the prominent subspherical genital papillae occur in pairs in each actinal interradial area, in line with the actinal plates. A swelling, probably the duct, leads downward to each papilla, which has a conspicuous terminal aperture.

The stomach is spacious with strong muscular attachments to the ambulacral ridge. The hepatic coeca reach nearly to the end of the ray but the intestinal coecum is small, with two short blunt lobes, each usually subdivided at the end into two.

Type.—Cat. No. 7625 U.S.N.M. Type of forma *beringensis,* No. E 1489 U.S.N.M.

Type locality.—Ten miles west of Point Franklin, Alaska (Arctic Ocean), 13.5 fathoms, sand, August 31, 1883 (42 specimens). The type locality of forma *beringensis* is station 3277, Bering Sea, latitude 55° 58′ 45″ N., longitude 161° 46′ 40″ W., 18 fathoms, sand, gravel, rocks, bottom, temperature, 43.2° F.

Distribution.—From southern Bering Sea and Aleutian Islands to Arctic Ocean, eastward to Dolphin and Union Strait, Nortwest Territories; and from low tide to 43 fathoms.

Forma *arctica.* From Cape Franklin to Bering Straits in the Arctic Ocean, thence south in the eastern part of Bering Sea to about latitude 60° where it very gradually intergrades with forma *beringensis.* On the west side of Bering Sea, south to the Commander Islands (lat. 55°). Vertical range 5 to 21 fathoms.

Forma *beringensis*. Southern and eastern Bering Sea (south of about lat. 60°), Shumagin Islands and Aleutian Islands, low tide to 43 fathoms; temperature range 35° to 46.2° F. Carrying very small young at 37.5° and 38° F.

Specimens examined.—Four hundred and ninety-three.

Specimens of forma arctica examined

Locality	Depth	Nature of bottom	Number of specimens	Remarks
	Fathoms			
Point Franklin, Arctic Ocean	13. 5	Sand	42	Type series No. 7625, John Murdoch.
Cape Lisburne, Arctic Ocean	5–10		1	No. 3628, W. H. Dall.
Arctic Ocean			1	No. 3622 (1669), W. H. Dall.
East Cape, Siberia			1	No. 6031, Dr. Robt. White.
Plover Bay, Siberia [1]	15–20	Rocky	10	No. 3576 (1650).
Do.			3	No. 3558 (1635), W. H. Dall.
Off Port Clarence , Alaska			4	No. 7627, John Murdoch.
Bering Strait			3	Nos. 1357, 1359, Wm. Stimpson.
Indian Point, Bering Strait	17	Gravel	1	No. 3582, W. H. Dall.
Bering Sea, 63° 37′ N., 165° 19′ W	12		1	Geo. M. Stoney.
Bering Sea, 61° 03′ N., 167° 55′ W			1	
Bering Sea, 60° 22′ N., 168° 45′ W			6	No. 15688, Geo. M. Stoney; intermediate.
Bering Sea, 60° 15′ N., 167° 48′ W	20. 5		1	Geo. M. Stoney.
Vicinity Bering Strait, 65° 25′ 28″ N., 171° 11′ 26″ W.	6–11		1	U. S. S. Corwin.
Station 3514, 59° 22′ N., 168° 21′ W	21	Fine gray sand	1	Bottom temperature 40.8° F.; intermediate.
Nikolski, Bering Island	Shore.		1	
Station 3518, vicinity St. Matthew Island, 60° 28′ N., 171° 42′ W.	36	Green mud	1	Bottom temperature 33.9° F.; intermediate.
North coast Siberia, latitude 67° 07′ N., longitude 173° 24′ E.	13–15	Stones with clay	2	Vega expedition.
Do.	12	Sand, stones	1	Do.
Bering Sea, 64° 30′ N., 171° 45′ W	25	Stones	1	Do.

[1] The young specimens (No. 16584) from 10 to 15 fathoms recorded by Verrill, 1914 p. 123, prove to be *L. groenlandica*, brooding eggs in the stomach.

Specimens of forma beringensis examined

Station	Locality	Depth	Nature of bottom	Bottom temperature	Number of specimens	Remarks
		Fathoms		*°F.*		
3235	Bristol Bay, Alaska	11	Pebbles, stones		2	
3236	do	14. 75	Gravel, sand, shells		1	
3240	do	14. 5	Fine black sand		2	
3241	do	14	Black mud	38	1	
3242	do	11	do		3	
3247	Mouth of Bristol Bay	17	Pebbles, stones	40. 6	2	
3250	do	17. 5	Gray sand	[1] 46. 2	10	
3251	North coast of Unimak Island	25. 5	Fine gray sand	37. 5	39	Some intermediate.
3252	do	29. 5	Black mud	[1] 44. 8	12	
3253	do	36	Mud, sand	35	11	
3255	do	43	Green mud, sand	37	2	
3261	do	27	Black gravel	41. 2	1	Aberrant.
3262	do	43	Black sand, rocks	40. 7	2	Do.
3265	Northeast of Unimak	38	do	39. 8	1	Do.
3266	do	24	Black sand	42	4	Do.
3269	do	16	Fine gray sand, shells	42. 3	1	
3271	do	25	Black sand	41. 9	1	
3272	do	31	Black and red sand	42	4	

[1] Probably incorrect; too high.

Specimens of forma beringensis examined—Continued

Station	Locality	Depth	Nature of bottom	Bottom temperature	Number of specimens	Remarks
		Fathoms		°*F*.		
3273	Northeast of Unimak	39	Gray sand, mud	38.5	2	
3277	North of end of Alaska Peninsula	18	Gray sand, rocks	43.2	4	
3278	do.	47	Fine gray sand	38.8	1	
3280	do.	36	do.	41	5	
3285	do.	35	Gray sand, black specks	41	3	
3286	Mouth of Bristol Bay near Alaska Peninsula.	37	Fine gray sand, shells, gravel.	41.5	3	
3287	do.	30	Coarse black sand	42	14	
3288	do.	15	Black gravel	[1] 45.5	3	
3290	do.	16	Gray sand, gravel		1	Intermediate, close skeleton.
3291	do.	26	Black sand, gravel	41.2	27	
3293	Bristol Bay	30	Fine gray sand	40	2	
3294	do.	30	Black gravel	41	14	
3295	do.	11.5	Fine gray sand		2	
3296	do.	24	Gray sand, black specks	43	5	
3297	do.	26	Gray sand	41.5	4	
3302	do.	30	Fine gray sand	40.2	20	
3303	do.	33	Black sand	39.5	8	
3304	Mouth of Bristol Bay	28	Fine gray sand		6	
3305	do.	23	do.	41.8	21	
3306	do.	33	do.	38.9	6	
3438	Vicinity of Pribilof Islands, 57° 06′ 30″ N., 170° 22′ 30″ W.	20	Fine gray sand, shells		7	Typical.
3439	do.	41	Fine black sand	[1] 44	4	
3442	do.	47	Black mud, shells	40	1	Largest.
3482	Vicinity of Pribilof Islands, 57° 18′ N., 170° 42′ W.	42	Green mud, fine gray sand	38.9	6	
3504	Vicinity of Pribilof Islands, 56° 27′ N., 169° 27′ W.	34	Fine gray sand, black specks	37.8	14	
3505	Vicinity of Pribilof Islands, 57° 09′ N., 168° 17′ W.	38.1	Fine gray sand	[1] 44	3	
3507	Bering Sea, 57° 43′ N., 164° 42′ W	31	do.	37.5	29	Intermediate.
3508	Bering Sea, 58° 33′ N., 164° 49′ W	23	do.	42	13	
3510	Vicinity of Pribilof Islands, 57° 12′ 30″ N., 169° 51′ W.	27	Black sand, shells	40.1	4	Variable.
3511	do.	39	Fine sand, black mud	37.2	7	
3512	do.	38	Fine sand, green mud	36.6	3	
3522	Vicinity of Pribilof Islands, 57° 58′ N., 170° 09′ W.	41	Coarse gray sand, gravel	35.7	2	
3536	Vicinity of Pribilof Islands, 57° 05′ N., 170° 35′ W.	40	Green mud, fine sand	42.4	20	Do.
3543	Vicinity of Pribilof Islands, 56° 41′ N., 169° 39′ W.	43	Black sand, shells	42.7	1	
3559	Vicinity of Pribilof Islands, 56° 56′ N., 169° 52′ W.	39	Gray sand, broken shells	42.5	27	Intermediate, with *f. arctica*.
3600	North coast Unimak Islands	9	Fine volcanic sand	40	4	Resembles *f. arctica*.
	Round Island, Coal Harbor, Shumagin Islands.	Low tide.			1	No. 6065, W. H. Dall.
	Sanborn Harbor, Nagai, Shumagin Islands				2	No. 6012, W. H. Dall.
	New Harbor, Unga, Shumagin Islands	Beach.			1	No. 6052, W. H. Dall.
	Unalaska	3–6	Stony		4	No. 6045, W. H. Dall.
	Iliuliuk Harbor, Unalaska	10	Shingle		4	(129–777).
	Nazan Bay, Atka	10–16	Sand		1	339 (1061), W. H. Dall.
	Chickagoff Harbor, Attu	5–7	Stony and muddy		1	6075, W. H. Dall.
	Bering Sea, 61° 03′ N., 167° 55′ W				1	Geo. M. Stoney.

[1] Probably incorrect; too high.

Specimens of Leptasterias mülleri examined

West coast of Sweden	1	Stanford University.
Finmark (Grotsund)	6	Riksmuseum, Stockholm.
Bohuslän (west coast Sweden)	9	Do.
Waideguba (40 fathoms)	3	Riksmuseum, Stockholm (Sandeberg expedition).
Iceland (Berufjord, 15 to 30 fathoms)	1	Do.
Iceland (Reikiavik, 8 fathoms)	1	Do.
Northwest of Bergen (90 to 200 fathoms)	5	Do.
Southwest of Nidingen (west coast Sweden)	1	Do.

Specimens of Leptasterias hyperborea examined

Spitzbergen (Ice Fjord)	1	Riksmuseum, Stockholm.
North of Spitzbergen (80° 65′ N., 14° 40′ E., 16 fathoms)	4	Do.
Spitzbergen (1 from Cross Bay, 2 fathoms)	2	Do.
Baffin Bay (67° 59′ N., 56° 33′ W., 98 fathoms)	3	Do.

Remarks.—There is no sharp line of demarkation between the two formae. There is a considerable number of specimens which may be referred to either. In Bering Sea north of about 60° the specimens are more like the Arctic race, although larger as a rule. Even as far south as the Pribilof Islands (as station 3559) large specimens resembling forma *artica* are found, but the crossed pedicellariae are larger than in the typical form from the Arctic Ocean. (Pl. 8, fig. 5*e*.) Occasionally (as stations 3290, 3600) well within the range of forma *beringensis*, specimens are found which closely resemble forma *arctica* abactinally. If there is any geographic significance to the large form from the southern part of Bering Sea, it is likely that these southern "intermediates" are simply variants of *beringensis* (especially as they have the larger crossed pedicellariae), and not of the typical phase, found in the Arctic Ocean.

The variety from the Aleutian and Shumagin Islands is rather variable and not typical but is more like forma *beringensis* than *arctica*. A series of drawings of pedicellariae on Plates 8 and 10 will show a real but slight difference between the northern and southern forms. They are introduced also for comparison with the crossed pedicellariae of *L. hyperborea* and *L. mülleri*.

Through the interest of Dr. T. Odhner, of the Naturhistoriska Riksmuseum, Stockholm, I have received specimens of a number of Arctic species for comparison. Especially useful have been the series of *L. hyperborea* and *L. mülleri*.

The question of whether these are distinct species or formae of the same species has been frequently raised. Von Hofsten (1915, p. 62) has followed Grieg (1907, p. 13) in considering them separate. The matter is of interest in determining the nearest relative of *arctica* in the North Atlantic and adjacent Arctic Ocean. Grieg (1907) writes:

> If we compare *Asterias hyperborea* with *Asterias mülleri* and nearly allied forms, we shall find that it has quite a different and coarser armature on the abactinal face of the disk. The most characteristic difference, however, is in the pedicellariae. In *Asterias mülleri* there are a few forficiform [straight] pedicellariae on the ambulacral papillae, or they are altogether wanting; in *Asterias hyperborea*, on the other hand, the pedicellariae are forcipiform [crossed] and arranged in groups.

The distinction is unfortunately not so simple. Crossed pedicellariae are present on the adambulacral spines of all the specimens of *mülleri* examined by me, and sometimes in fair numbers. They are also abundant on the same spines of *hyperborea.* The abactinal spines do average larger on *hyperborea* and are often more numerous than in *mülleri.* There is, however, a small but distinguishable difference in the crossed pedicellariae. (Pl. 8, figs. 4, 4*a*, *b;* pl. 11, figs. 1, 1*a*–1*c*.) In *hyperborea* the pedicellaria is wider (pl. 11, figs. 1, 1*c*) as seen in profile, with a larger terminal lip which is broader than in *mülleri.* The large specimen of *hyperborea* from Ice Fjord, Spitzbergen, has numerous conspicuous spatulate straight pedicellariae similar to those of *arctica.* (Pl. 11, figs. 1*d*, 1*e*.) This example has R 82 mm., and is much bigger than average specimens of *mülleri.*

Dr. A. Djakonov, of the Zoological Museum, Academy of Sciences, Leningrad, made comparisons of specimens of *L. mülleri*, *L. hyperborea*, and *L. groenlandica* at my request and wrote me as follows:

> My investigations have led me to the conclusion that: 1. Kalischewsky had an incorrect idea of these species and what he held for *L. hyperborea* was really *L. groenlandica* in all cases. 2. *L. groenlandica* is a good species and is clearly different from *mülleri-hyperborea.* 3. *L. hyperborea* can only with great difficulty be distinguished from *mülleri* and is, as it seems, only its arctic form, there being intermediate specimens between them. 4. *L. mülleri* is not to be met with eastward of middle Murman coast of northern Russia; records of *mülleri* from the coast of northern Siberia are referable to *hyperborea.*

I think the relationship of *arctica* is with *mülleri* rather than with *hyperborea.* The crossed pedicellariae of *arctica* are more like those of *mülleri* than of *hyperborea*, and the general appearance of *arctica*, especially of forma *beringensis*, is much like that of *mülleri.* It is likely that the two species intergrade, probably through a series of slightly differentiated geographic forms.

Verrill (1909, p. 553) has expressed the opinion that *hyperborea* and *arctica* are the same, but in 1914 he recognized *arctica* as a full species without mentioning his previous identification, nor pointing out the close similarity of the two.

Arctica seems to be the equivalent of *mülleri* in Bering Sea and the Arctic Ocean to the north. It differs from *mülleri* in having either a closer, more capitate abactinal spinulation or numerous spatulate straight pedicellariae or both in varying degrees. The south Bering Sea form of *arctica* is larger than *mülleri* with heavier spines and more numerous pedicellariae of both sorts.

LEPTASTERIAS HYLODES, new species

Plate 10, Figures 5–11; Plate 17; Plate 18, Figures 1–3

Diagnosis.—Differing from *L. arctica* in having uniform, rather close-set, slender, terete, often slightly tapered, striated but noncapitate, heavily sheathed abactinal spinelets, the carinal series of which is not at all differentiated from the other spines. The species occurs in a dwarfed form, sexually mature at R 15 to 17 mm., in which the skeleton and spinelets are relatively more delicate than in the large specimens, and more delicate than in corresponding sizes of *L. arctica.* Type, R. 39 mm., r 9 mm., R = 4.3 r; breadth of ray, just beyond base 12 to 14 mm. Rays well arched with rounded sides and plane actinal surface, slender to medium stout, gently tapering from a slightly swollen base to a blunt extremity.

Description.—The surface of the body has the appearance of being covered with close-set slender, subterete, uniform, small spinelets emerging, in alcoholic specimens, from a pulpy sheath, carrying in the small specimens usually few crossed pedicellariae. The spines are pretty uniformly spaced, but vary considerably in number. In smaller examples (as with R 25 to 30 mm.) from station 2847 the spinelets appear as a coarse nap, with very narrow interspaces between the sheaths of neighboring spinelets; in others there are much wider interspaces with an evident arrangement of spinelets in longiseries, although sometimes with no great regularity. The abactinal spinelets are typically very much slenderer than in *arctica*, terete, slightly tapering, terminally striated in large examples and bluntly pointed. In typical, small, deep-water examples (as stations 2845, 2846, 2847, 2851, 2856) this character is accentuated, the spinelets being very delicate and sometimes almost setalike—quite different from the stout capitate spinelets of *arctica*. But in some localities the spinelets are heavier, slightly clavate, with a rounded striated summit (as stations 4281, 3260, 3261, 3265). In *hylodes* there is no crowding of the carinal spines, nor are they distinguishable by greater size from the others, except in a few aberrant specimens, where the discrepancy is slight. One of the most characteristic features of this species is the uniform appearance of the abactinal area—entirely unlike that of typical *arctica*. This is as well marked in the relatively gigantic type (and in an equal sized specimen from station 2847) as it is in the general run of specimens which are small, though sexually mature (as station 2856). In the type the dorsal spines are 0.90 to 1.2 mm. long.

The supero and infero marginal spines form two usually very regular lateral series, and in all but the smallest specimens there is an incomplete series of actinals, the number varying from a few spines to a nearly complete series. There are thus three ventrolateral rows of spines, which in typical specimens are similar to the dorsals, though usually larger, and in the case of the inferomarginals and actinals slightly heavier in small examples and markedly so in large ones. There is great variability in the thickness of these marginal and actinal spines, just as there is in the dorsal. A short series of smaller intermarginal spinelets is generally present. The superomarginals have a complete wreath of pedicellariae, the inferomarginals a complete or an incomplete wreath and the actinals a tuft on the outer side, the number of pedicellariae variable but not high. The marginal and actinal spines in the largest examples are less regular than in the small.

Adambulacral spines slender, subterete, slightly tapered, bluntly pointed, one or two to a plate in fairly regular alternation, except on the first dozen plates which may carry mostly one, or mostly two, spines. The adoral adambulacral plates usually three in contact behind the oral plates (and the first rather the longest), each carry but one spine. The large type (station 2851) has two spines on most of the plates on the proximal half of ray.

Oral plates small, the spines two or three as in *arctica*. Where there are two, which seems to be more often, the furrow or smaller marginal is suppressed. In the type each plate has a short tapering blunt spine at the inner end and another, the suboral, at the outer. The latter may carry a large unguiculate pedicellaria, or only one or two crossed pedicellariae.

Papulae usually not conspicuous, one or two to the abactinal areas (frequently only one in small examples); two, three, or less often four intermarginally (one or two in small examples); one to three in actinal areas. The skeleton is somewhat more compact, less open, than in *arctica* and the papular areas are consequently smaller.

Straight pedicellariae. (Pl. 10, fig. 9.) A few relatively large unguiculate pedicellariae are present on the abactinal surface, especially near the interradii, in the intermarginal and actinal channels, and in the actinal interradial channel. Those of the abactinal surface may be nearly or quite as long as the slender spines and considerably stouter. Similar but smaller pedicellariae occur on some of the suboral and proximal adambulacral spines but not at all constantly. Smaller pedicellariae without teeth but with a notch in the end of one jaw, and the tips of the jaws crossed, are abundant, as in *arctica*, along the furrow face of the adambulacral plates.

Crossed pedicellariæ very variable in number but in small specimens generally few, form a circle around the summit of the prominent sheath of the abactinal and marginal spines, and tufts on the outer side of the actinal and adambulacral spines. In most of the typical deep-water specimens the pedicellariæ are few. In specimens from station 2856, the dwarfed deep-water form, there are only two to five pedicellariæ surrounding the dorsal spines, four to eight around the marginals, and one to three on the adambulacral spines. Typical pedicellariæ from station 2856 are figured (pl. 10, figs. 6 and 7). The abactinal are about 0.21 to 0.225 mm. long (in the large type 0.20 to 0.25 mm.). The adambulacral may be slightly longer. Some of the furrow spine pedicellariæ differ from the abactinal, as in *artica*, in having a longer terminal denticulate portion when seen in profile. These differentiated pedicellariæ seem to increase in numbers rather more rapidly than the others, as the animal grows, and they appear to be less numerous in this species than in *artica* but it is difficult to achieve any degree of accuracy since variation in the total number of pedicellariæ is so wide. (Pl. 10, fig. 7.) The crossed pedicellariæ are more numerous than usual in the large specimen from station 2847 (pl. 10, figs. 5, 5*a*), and the sheaths carrying them are especially prominent, forming near the tip of spine a good-sized flange of pulpy tissue carrying 6 to 12, or even more pedicellariæ, which measure about 0.27 mm. in length. The inferomarginals carry upward of 25. In contrast to this, the type specimen from station 2851 (pl. 10, fig. 8) has slenderer abactinal spines with only two to five pedicellariæ each (0.20 to 0.25 mm. long), and upward of 20 on the marginal spines.

Madreporic body small, variable, situated about 0.6 r from center and with a circle or half circle of spinelets guarding it.

Variations.—The general appearance of this species varies less than that of *arctica;* but there is nevertheless considerable difference in specimens from the same station. Some of the differences, such as the spacing and robustness of spines, have been stated in the description. It may be added that there is diversity in the robustness of the rays as well as in the proportions of R to r.

The specimens from the greatest depth, 68 fathoms, station 2856, are all small, although most of them are sexually mature, having well developed gonads. The largest has R 24 mm.; the largest from station 2846, 44 fathoms, has R 35 mm.; that from station 2847, 48 fathoms, has R 39 mm.; from station 2845, 42 fathoms, 30 mm.; from station 2851, 35 fathoms, 39 mm.; from station 3259, 25.5 fathoms, 33 mm.; from station 3265, 38 fathoms, 37 mm. Thus the maximum size ranges roughly from 24 mm. to 39 mm., the smallest being from 68 fathoms. The specimens from stations 3213, 3214, 3215, 3217, 3218 are also small, and are all within these extremes—the majority having R less than 30 mm.

The specimens from Popoff Strait, the Shumagin Islands, and Agattu are not typical. They are small and the spinelets are more widely spaced than in average deep-water examples. Crossed pedicellariæ are few on all spines.

Specimens from stations 3265, 3266, and 3291 have given considerable trouble on account of their variability and general resemblance to *L. arctica*. Those from 3265 are referable to *hylodes* except one which if considered alone would be regarded as *L. arctica* forma *beringensis* with rather slender spines, and is so recorded. Specimens from 3266 are like this single example from station 3265 except one which is referable to *hylodes*. Four have been recorded as aberrant *arctica*. Out of 28 specimens from station 3291, one is referable to *hylodes* and the others to *L. arctica* forma *beringensis* with unusually slender, but fairly well spaced spines. Other specimens of *arctica* which approach *hylodes* are found at stations 3242 and 3262. Typical *hylodes* is very distinct from *arctica* and ranges, through various small races, into Japanese waters. It is found in its most typical form south of the Alaskan Peninsula, west of Afognak Island. Whether these aberrant specimens of *arctica* from the region of Bristol Bay are intermediates, or the results of crossing with *hylodes*, specimens of which were found in the same bottles (as stations 3265, 3266, 3291) must remain undecided. It is probable that *hylodes* does not range far into southern Bering Sea.

Anatomical notes.—The skeleton is essentially like that of *arctica*, with surprisingly little difference when allowance is made for the disparity in size. In *hylodes* the abactinal skeleton consists almost entirely of primary, mostly 3-lobed plates with relatively few intermediate ossicles such as multiply in large examples of true *arctica*, or its southern Bering Sea form. Corresponding to the first 10 inferomarginals there are 29 or 30 adambulacrals. The series of actinal plates of a specimen from station 2847 with R 22 mm. extends along the ray about two-thirds R from center, or to the twelfth inferomarginal (a little over half length of ray measured on side).

The gonads are fully developed in an example with R 17 mm. from station 2856. They open on the ventral surface, close together, on either side of the interradial furrow, and on a level with the actinal plates, or a trifle higher. The aperture is at the summit of a conspicuous thick papilla, when the products are mature, and is often guarded by a large straight pedicellaria. The testes extend fully half the length of ray and consist of a number of relatively slender, lobulated lobes, while the ovaries are shorter, more compact, with a few subspherical lobes, or without lobes. In a specimen from station 3215, May 21, temperature 38.5° F., the gonads are not mature, although they appear to be on the way to maturity. Those from station 3265, June 25, temperature 39.8° F., have good-sized gonads, apparently not yet mature, however. In examples from station 2847, July 31, temperature

42° F., the eggs appear to be fully developed and relatively few and large; in specimens from 2856, August 22, temperature 44° F., the gonads are also mature. None of the specimens has young.

Type.—Cat. No. E 1490, U.S.N.M.

Type locality.—Station 2851, vicinity of Shumagin Islands, 54° 55′ N., 159° 52′ W., 35 fathoms, gray sand, broken shells, bottom temperature 44.8° F.

Distribution.—In a typical form, south of the Alaska Peninsula and Aleutian Islands, 25 to 68 fathoms, but ranging into shallower water.

Specimens examined.—Two hundred and sixteen.

Specimens of Leptasterias hylodes examined

Station	Locality	Depth	Nature of bottom	Bottom temperature	Number of specimens	Remarks
		Fathoms		° *F.*		
2845	South of Unimak Island, 54° 05′ N., 164° 09′ W.	42	Coarse black sand	42	8	U. S.N.M.
2846	South of Unimak Island, 54° 08′ N., 162° 44′ W.	44	Gravel	42	7	Do.
2847	Vicinity of Shumagin Islands, 55° 01′ N., 160° 12′ W.	48	Fine gray sand	42	17	Do.
2850	Vicinity of Shumagin Islands, 54° 52′ N., 159° 46′ W.	21	Broken shells	48. 2	2	Do.
2851	Vicinity of Shumagin Islands, 54° 55′ N., 159° 52′ W.	35	Gray sand, broken shells	44. 8	1	Do.
2856	Off Afognak Island, 58° 07′ N., 151° 36′ W.	68	Gray shells, black specks	44	47	Do.
3213	South of Unimak Island, 54° 10′ N., 162° 57′ 30″ W.	41	Black sand		12	Do.
3214	South of Unimak Island, 54° 13′ N., 163° 06′ W.	38	Gray sand, gravel		2	Do.
3215	South of Unimak Island, 54° 14′ 40″ N., 163° 24′ W.	43	Gravel	38. 5	10	Do.
3217	South of Unimak Island, 54° 14′ 50″ N., 164° 06′ W.	42	Black gravel		11	Do.
3218	South of Unimak Island, 54° 15′ 50″ N., 164° 21′ W.	41	Black sand	37. 7	15	Do.
3219	South of Unimak Island, 54° 14′ N., 164° 35′ W.	59	do	38	3	Do.
3220	South of Unimak Island, 54° 15′ N., 165° 06′ W.	34	Gravel, broken shells		1	Do.
3232	Bristol Bay	10. 5	Pebbles, stones		2	Not typical.
3259	North coast of Unimak Island	25. 5	Fine gray sand	37. 5	26	Do.
3260	do	13	Fine black sand	42	2	U.S.N.M.
3261	do	27	Black gravel, pebbles	41. 2	11	
3265	Northeast of Unimak	38	Black sand	39. 8	25	
3266	do	24	do	42	1	Do.
3291	Mouth Bristol Bay, near Alaskan Peninsula.	37	Fine gray sand, shells, gravel.	41. 5	1	U.S.N.M. Small form.
4281	Chignik Bay, Alaska Peninsula	42	Green mud	47	1	Small form.
4284	do	26	Green mud, sand, rocks		1	Do.
4285	do	31–59	Gray sand, broken shells	47. 2	1	Do.
	Popoff Strait, Alaska	(1)			1	W. H. Dall, 4191.
	Round Island, Coal Harbor, Shumagins	(2)			2	W. H. Dall, 6065.
	Captains Harbor, Unalaska	9–15	Stony, muddy		1	W. H. Dall, 6075.
	Agattu Island, Aleutians	(3)			2	Albatross, 1906.
	Kadiak Island				3	Albatross, 1888.

[1] Lowest water.
[2] Beach neap tide.
[3] Low tide.

Remarks.—In the foregoing description all the comparisons have been with *L. arctica*, but *hylodes* resembles, as closely, the arctic *L. hyperborea*. This species is very rare, poorly understood, and usually confused with *L. mülleri*. *L. hylodes* resembles *hyperborea* in having very numerous, close-set abactinal spines among which the carinal series is not readily distinguishable. It differs in the form of the straight pedicellariae (which are rarely present in *hyperborea*), and in the form of the crossed pedicellariae. (Compare pl. 11, figs. 1, 1*d*, with pl. 10, figs. 5, 6, 9.) When compared side by side with *hyperborea*, the rays of *hylodes* are seen to be thicker and shorter and the abactinal spinelets much more numerous and shorter.

LEPTASTERIAS ORIENTALIS Djakonov

Plate 11, Figures 2, 2*a*–2*h*; Plate 19, Figures 2, 3; Plate 20, Figure 3

Leptasterias orientalis Djakonov, Neue Seesterne aus dem Ochotskischen Meer. II. *Leptasterias orientalis* sp. n., Compt. Rend. Acad. Sci. U. R. S. S., 1929, p. 277.

Diagnosis.—Rays five, of medium stoutness, tapered, slightly swollen at base; disk small; spinelets slender, tapered, with heavy wreaths of pedicellariae, rather uniformly and closely placed, but without longiserial order except on sides and actinal surface. Differing from *L. hylodes* in having much more numerous crossed pedicellariae, especially abactinally; less numerous abactinal spinelets; and in having more numerous shank teeth on the jaws of the crossed pedicellariae. Differing from *L. hyperborea* in the form of both crossed and straight pedicellariae and in the greater abundance of the crossed pedicellariae. R 55 mm., r 9 mm. R=6 r; breadth of ray at base, 13 mm.

Description.—Spinelets slender, tapering, pointed, less numerous, longer, and with conspicuously larger circumspinal clusters of pedicellariae than in *hylodes*. Across the abactinal area, at base of ray, 13 to 15 spinelets can be counted. The wreaths touch one another and neither the carinals nor dorsolateral spines (except adjacent to superomarginals) form longiseries. Papulae singly or in groups of two or three emerge between the spinelets.

The marginal and actinal spinelets are longer than the dorsolateral and are clad in heavy stoles of pedicellariae, which on the actinals are on the outer side of the spine. One series of actinals extends nearly to end of ray while a second occupies the basal third. Only one series is present in the specimen from station 5024.

First six or seven adambulacrals monacanthid; then irregularly monacanthid and diplacanthid; then monacanthid on outer half of ray (mostly monacanthid throughout on small example). The furrow spines of alternate plates are set a little further furrowward, giving the appearance of two series of spinelets along the margin, or even three on the basal half of the ray. Spines with heavy cluster of crossed pedicellariae.

The apertures of the gonoducts are marked by two prominent papillae in each actinal interradial area (near the sixth or seventh adambulacral plate), usually guarded by a large straight pedicellaria.

Mouth plates with one slightly curved, tapered, blunt actinostomial spinelet about as long as median suture and carrying one or two lanceolate straight pedicellariae; and one suboral, longer straight spinelet similar to the adambulacral spines.

This usually carries, in addition to several crossed pedicellariae, one or two prominent, narrow, straight pedicellariae with the end of the jaw notched or pointed.

Crossed pedicellariae (pl. 11, figs. 2*c*, 2*d*) measure 0.27 to 0.31 mm. long and have rather numerous teeth especially in the outer of the vertical rows of shank teeth. The specimen from station 4810 (pl. 11, fig. 2*a*) has smaller pedicellariae (length about 0.2 mm.) and is intermediate in this respect with that from off the Bay of Sendai (station 5047) which represents another, closely related, race. In this form the pedicellariae are still smaller (about 0.18 or 0.19 mm.) with numerous very small shank teeth (pl. 11, fig. 2*b*), but are not nearly so numerous as in *orientalis.*

Straight pedicellariae 0.7 to 1 mm. long, sparingly present in intermarginal channel and between proximal actinal spines; two are usually present, near the apertures of gonoducts, in each actinal interradial area. The jaws may be narrowly spatulate with a few teeth or tapered and without teeth. (Pl. 11, fig. 2*e*.) Small narrowly lanceolate ones are present abundantly along the furrow face of the adambulacral plates; a few larger ones on the oral and proximal adambulacral spines.

Type.—Cat. No. 5164, Museum of the Academy of Sciences, U. R. S. S., Leningrad.

Type locality.—Okhotsk Sea, 57° 36′ N., 140° 34′ E., 106 meters, mud, bottom temperature −1.4° C.

Distribution.—Okhotsk Sea to Sea of Japan, cold area.

Specimens examined.—Okhotsk Sea, 57° 36′ N., 140° 34′ E., 106 meters, mud (station 9), hydrographic expedition, Pacific Ocean, August 14, 1918, from the Academy of Sciences, U. R. S. S., Dr. A. Djakonov, one specimen (topotype).

Station 5024, off Cape Patience, Saghalien, 48° 42′ 10″ N., 144° 59′ 30″ E., 67 fathoms, sand, pebbles, bottom temperature 30.9 F., one specimen (*Albatross*, 1906).

In addition to the above, two specimens with R 21 mm., from station 4810, off Cape Sirakami (Hokkaido), west entrance to Tsugaru Strait, Japan, 195 fathoms, fine gray sand, bottom temperature 44.7° F. (not typical).

Remarks.—The occurrence of this form in truly arctic temperatures of the Sea of Okhotsk suggests that it may be a derivative of the high arctic *hyperborea.* It appears to be more closely related to *hyperborea* than is *hylodes;* both resemble *hyperborea,* however.

Orientalis has much heavier stoles of pedicellariae than *hyperborea.* For the form of the crossed pedicellariae of *hyperborea* see Plate 11, Figures 1, 1*a*, 1*b*, 1*c*. These are relatively broader. The straight pedicellariae of *hyperborea* have wider, spatulate jaws with more numerous teeth. (Pl. 11, figs. 1*d*, 1*e*.)

The two specimens from the Sea of Japan are not at all typical. The crossed pedicellariae are smaller and the straight pedicellariae are much slenderer, with more delicate teeth (resembling the slenderest type of *hylodes*). They are probably examples of a small race, living in the cold water of the Japan Sea, intermediate between *orientalis* and an undescribed race found in the warmer waters off the east coast of Hondo (station 5047). Station 4810 is at the southern limit of winter ice in the Sea of Japan.

LEPTASTERIAS FISHERI Djakonov

Plate 11, Figures 3, 3*a*–3*g*; Plate 20, Figures 1, 2; text Figure 1

Leptasterias fisheri Djakonov, Neue Seesterne aus dem Ochotskischen Meer. I. *Leptasterias fisheri* sp. n., Compt. Rend. Acad. Sci. U. R. S. S., 1929, p. 233.

Diagnosis.—A relatively large, 5-rayed species having all the spines arranged in spaced longiseries. Rays slender, very gradually tapered, well arched; disk small; R 85 mm., r 15 mm.; R = 5.66 r; breadth of ray at base, 15 mm. Carinal spines blunt, one to several to a plate, in a prominent, irregular longiseries; on either side two fairly regular well spaced dorsolateral series of smaller spinelets; then two marginal series, successively larger and very regular, one spine to a plate; then two actinal series, also regular and slightly larger; at base of ray a few small intermarginal spinelets; all with neat stoles of normal-sized crossed pedicellariae; adambulacrals two and one, alternating; large intermarginal and actinal, toothed, straight pedicellariae. Differing from *L. arctica*, *L. groenlandica*, and allies in the longiserial arrangement of the well spaced dorsolateral spines and in the conspicuously longer rays and heavier bivalved pedicellariae.

Description.—Carinal spines short (0.9 to 1.1 mm.), robust, round-tipped, one to three to a plate, forming a conspicuous, irregular series in marked contrast to the dorsolateral spinelets which are slenderer, shorter, and stand in two fairly regular well-spaced series. Outside of these there is a very regular series of similar, but larger, bluntly pointed superomarginals (1.5 to 1.8 mm.), one to a plate; then outside of these and separated therefrom by about their own length is a very regular series of pointed inferomarginals, one to a plate, about 0.2 to 0.23 mm. long. The superomarginals are rather high on the side of ray, whereas the inferomarginals define ambitus as viewed from above, and may be easily mistaken for the superomarginals, inasmuch as directly below them there is a series of exactly similar, but a trifle longer, actinals which extend very nearly to the tip of ray. A second series of similar actinals extends about half the length of ray. There are thus on either side of the carinals, two series of small dorsolaterals, one series of larger superomraginals and then three series of still larger subequal spines, the upper of which is inferomarginal. These spines are surrounded at base by a neat wreath of crossed pedicellariae (a tuft only on the inner actinals) and in the actinal and intermarginal channels are fairly numerous bivalved pedicellariae about 1 to 1.2 mm. long. (Pl. 11, fig. 3*a*, *b*.) On the disk the spinelets are unequal, irregularly spaced like the carinals.

Between these regular longiseries are longiseries of small groups of papulae, two to four dorsally, one or two laterally and ventrally.

The carinal, marginal, and actinal plates are fairly definitely four lobed and are directly imbricated in series, without secondary ossicles except sporadically, as shown in text Figure 1. The exact form and relations of the dorsolateral plates are indicated in the figure (dotted plates).

Generally speaking, the adambulacral spines, which are slender, tapered, pointed, and heavily laden with crossed and straight pedicellariae (pl. 11, fig. 3*c*) alternate two and one along the furrow, except at the mouth angle, where the first few plates carry one only. Adoral carina narrow, consisting of three pairs of contiguous plates, the fourth pair slightly separated. The first two plates are distinctly longer than the third, and the two combined are about as long as the mouth plates.

At the inner end of the mouth angle are two blunt actinostomial spines, and on the narrowed actinal surface the two suboral spines are crowded one behind the other. Actinostome small, sunken, having the general appearance of *Evasterias*.

Crossed pedicellariae (pl. 11, fig. 3), rather numerous confined to spinal sheaths, as noted above. The abactinal are 0.32 to 0.34 mm. long.

Straight pedicellariae of two sorts: (1) Rather generalized, lanceolate ones (either robust or medium slender) of various sizes, on the adambulacral and oral spines (somewhere around 0.7 mm. long, pl. 11, fig. 3*c*), and numerous smaller pedunculate ones at base of same spines; (2) larger toothed ones (pl. 11, figs. 3*a*, 3*b*) in intermarginal and actinal channels and very rarely on abactinal surface (1 to 1.2 mm. long). Two or three of these stand near the genital apertures on the very narrow actinal interradial region.

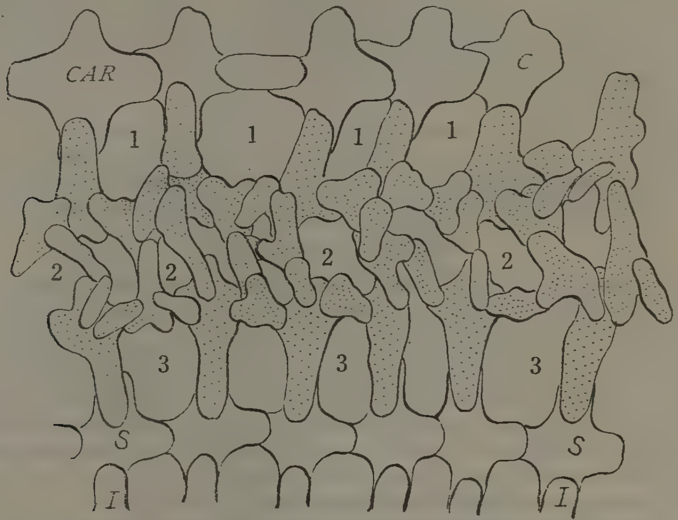

Figure 1.—Leptasterias fisheri Djakonov. Plan of the abactinal skeleton between the carinal and inferomarginal plates, base of ray to left. The dorsolateral plates are dotted; × 8. *CAR*, carinals; *I*, inferomarginals; *S*, superomarginals; *1–3*, the three longiseries of dorsolateral skeletal intervals

Madreporic plate 2.5 mm. in diameter, situated at middle of r, at top of axillary channel.

Gonads attached to body wall at base of ray between the superomarginal and inferomarginal plates. In one interradius the two genital papillae can be demonstrated just back of the adoral carina.

Type.—Cat. No. 5139, Museum of the Academy of Sciences, U. R. S. S., Leningrad.

Type locality.—Okhotsk Sea, 50° 03′ N., 144° 08′ E., 110 meters, mud.

Distribution.—Okhotsk Sea, Gulf of Tartary.

Specimen examined.—Okhotsk Sea, 50° 03′ N., 144° 08′ E., 110 meters, mud.

Remarks.—I am indebted to Dr. A. Djakonov for the specimen upon which the illustrations and the above account are based.

This species, like *orientalis*, lives in the very cold environment of the Okhotsk Sea. It appears to belong in the *hyperborea-groenlandica* section of *Leptasterias*, from which, as well as from all other 5-rayed north Pacific *Leptasterias*, the species can be distinguished by the regular dorsolateral longiseries of spinelets. In a general way *fisheri* resembles *L. tenera* forma *compta* of New England waters. In *L. tenera*, which is a small species, the spaced spinules are heavily wreathed but the carinals are similar to other abactinals, and no large bivalved pedicellariae are present in my specimens. The crossed pedicellariae resemble those of *fisheri* in details, but are only 0.2 to 0.22 mm. in length abactinally.

L. leptalea Verrill was based upon a very small specimen from southern Alaska. Since the type is lost and no other specimen is known, it is doubtful if the species can be surely identified, as no details are figured. The crossed pedicellariae are said to be of "unusually large size, with strongly curved blades, numerous in groups around the dorsal spines and *on the papular areas*." This does not apply to *fisheri*.

LEPTASTERIAS LEPTALEA Verrill

Leptasterias leptalea VERRILL, Shallow-water Starfishes, 1914, p. 119, pl. 18, fig. 3.

The 5-rayed type of this species, the ventral side of which is figured by Verrill (pl. 18, fig. 3), is said to be from Sitka. The only locality mentioned in the description is Virgin Bay, Prince William Sound, Alaska. The type can not now be located at the Peabody Museum, Yale University. A small 6-rayed specimen from Sitka (No. A. 275) collected by W. R. Coe, 1899, and labeled *leptalea* is obviously not the type, nor this species, there being six rays, two or three superomarginal spines, and small crossed pedicellariae. It is possible that the *label* may have been attached to the wrong specimen, which resembles *L. asteira*.

Verrill's small figure of the ventral surface lacks pertinent detail. Such figures of *Leptasterias* without a dorsal view are of little value. It resembles *L. groenlandica*, some specimens of *arctica*, and some of *hylodes*, and even *hyperborea* and *orientalis*. From the standpoint of locality *hylodes* is the most likely, if the description fitted. The dorsal spinelets of *hylodes* can hardly be described as "not numerous, conical, relatively stout;" nor are the crossed pedicellariae "of unusually large size with strongly curved blades;" nor do they ever occur on the papular areas. The straight pedicellariae are not "small, ovate."

The following is the original description:

> A small and very delicate 5-rayed species. Radii, 2.5 mm. and 15 mm.; ratio, 1 : 6. Rays terete, evenly tapered. Dorsal ossicles relatively strong, thickened, especially those in the median rows. Dorsal spines not numerous, conical, relatively stout, usually standing singly, one to an ossicle, and forming three or five rather irregular rows. Ocular plate relatively large, bearing a dense cluster of small spines. Minor pedicellariae of unusually large size and with strongly curved blades are usually numerous in groups around the dorsal spines and on the papular areas. Adambulacral spines mostly two to a plate, or alternately one and two distally, very slender, terete, often slightly clavate. Lower marginal spines, which are much larger, acute, conical, like the dorsals,

but longer, form a single row next the adambulacrals, or there may be two to a plate, proximally, in the larger specimens. The synactinal plates appear to be few and small, or altogether lacking in our examples, but may occur in larger ones. Upper marginal spines form a single row and resemble the dorsals in form and size. Major pedicellariae few, small, ovate.

The ambulacral feet are in four rows, but the adjacent rows form only a zigzag line, so that they sometimes appear almost biserial.

LEPTASTERIAS GROENLANDICA (Lütken)

Plate 8, Figures 1, 1*a*–1*e*, 2, 2*a*, 2*b*, 3, 3*a*; Plates 21–23; Plate 24, Figures 1, 2

Asteracanthion groenlandicus LÜTKEN, Vidensk. Meddel. N. Forening i Kjöbenhavn, 1857, p. 29.—STEENSTRUP, Forh. skand. Naturf., 1857, p. 228.—DUNCAN and SLADEN, Echinodermata of the Arctic Sea, etc., 1881, pp. 27–29, pl. 2, figs. 9–12.

Asterias cribraria STIMPSON, Proc. Boston Soc. Nat. Hist., vol. 8, 1862, p. 270.—PERRIER, Rév. Stell., 1875, p. 65.—LUDWIG, Zool. Jahrb., 1886, p. 288; Fauna Arctica, vol. 1, p. 482.—BELL, Proc. Zool. Soc., 1881, pp. 494, 505.

Asterias groenlandica STIMPSON, Proc. Acad. Nat. Sci., Phila., 1864, p. 142.—VERRILL, Amer. Nat., vol. 43, 1909, p. 553.—LIEBERKIND, Vidensk. Medd. fra Dansk naturh. Foren., vol. 72, 1920, p. 121, text figs. 1–4.

Asterias groenlandica var *longimana* KALISCHEWSKY, Mem. Acad. Sci., St. Petersburg, ser. 8, vol. 18, no. 4, 1907, p. 41.

Asterias hyperborea KALISCHEWSKY, 1907; according to A. Djakonov, letter, 1929.

Asterias inermis BELL. Proc. Zool. Soc., 1881, p. 512, pl. figs. 2, 2*a*. (Fisher, Ann. and Mag. Nat. Hist., ser. 9, vol. 18, 1926, p. 198.)

Asterias spitzbergensis DANIELSSEN and KOREN, Norwegian North Atlantic Exp., Asteroidea, 1884, p. 5–7, pl. 1, figs. 1–11.

Leptasterias groenlandica VERRILL, Proc. U. S. Nat. Mus., vol. 2, 1879, p. 151.

Asterias mülleri groenlandica VON HOFSTEN, Die Echinodermen des Eisfjords, Kungl. Svenska Vet. Akad. Handl., vol. 54, no. 2, 1915, p. 60 (distribution).

Ctenasterias cribraria VERRILL, Shallow-water Starfishes, 1914, p. 148, pl. 25, figs. 3, 4, text fig. 7.—A. H. CLARK, Rep. Canadian Arctic Exp., 1913–1918, vol. 8, 1920, p. 8*c*.

Leptasterias obtecta VERRILL, Shallow-water Starfishes, 1914, p. 144. (Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 12, 1923, p. 599.)

Diagnosis.—Rays five, slender to robust, tapering, bluntly pointed. Recognizable usually by the broad but short dorsolateral papular areas which sometimes reach from the carinal to the superomarginal plates, these separated by irregular, sometimes anastomosing transverse trabeculae bearing small spinelets, either spaced singly or in spaced small groups. Superomarginal spines usually two or three; inferomarginals usually two; actinals, one, all surrounded by complete, dense wreaths of pedicellariae. Adambulacral plates diplacanthid proximally. Dimensions of a large specimen: R 55 mm., r 11 mm. R = 5 r; breadth of ray at base, 14 mm.; of a small breeding specimen (Bering Strait) R 17 mm., r 4 mm., R = 4.2 r; breadth of ray at base, 6 mm. A very variable species.

Description.—In order to render this variable species recognizable by description, it will be necessary to consider first the more prevalent forma, which has a characteristic appearance. This is the form made known by Stimpson under the name *cribraria* and later by Danielssen and Koren as *spitzbergensis*.

The rays vary from slender to rather stout and in small specimens may be inflated and tumid. Plates of abactinal skeleton slender and arranged in numerous transverse bars, fairly close together, with intervening transversely elongate papular areas—especially adjacent to marginal plates and on outer part of ray. But it is not uncommon to find these narrow areas all along the side of the abactinal area, and some of them extend without interruption from the carinal to the superomarginal plates. They are accentuated by drying. The abactinal spinelets are small (0.4 to 0.7 mm. long) of variable caliber, but generally slender, distinctly clavate to subcylindrical on the one hand or subcapitate on the other. They are rather numerous and on account of the structure of the skeleton form many transverse lines. They stand on the trabeculae in lines either singly or in linear groups of two or three, and increase in thickness toward the carinals. The latter are generally the largest, subcapitate or capitate, striate, and form a definable irregular longiseries. In most specimens there is a *supramarginal* channel, immediately above which the spinelets form a fairly well defined longitudinal dorsolateral series which is more prominent in forma *groenlandica*. Even in forma *cribraria* there is considerable variation in the caliber, shape, and number of the abactinal spinelets. In alcoholic specimens the spinelets appear to stand in transversely oriented groups, surrounded by deep narrow creases in the pulpy integument.

Superomarginal spines in a transverse series of two, three, or four, the median (or second from the top) generally the largest. They vary from slender to stout, and from terete, slightly tapering to cylindrical or clavate, depending upon the robustness of the general armature. On the same specimen the spines increase in thickness and become much shorter toward the end of the ray, and they are subequal to or slightly larger than the abactinal spines. The series of combs is generally quite regular. Below them is a well-defined, and in some specimens rather broad, intermarginal channel (showing large papular areas when dried). There is great variation due in part to the shrinkage of the specimen in alcohol and in part to the size of the gonads. Below this are two series of inferomarginal spines and one of actinal. The latter extends a third or half the length of ray. These three series, or two distally, have spines similar in form to the superomarginals but are a little stouter and longer. In some examples the first half dozen inferomarginal plates are monacanthid. The terminal plate (quaintly termed the "eyelid" by Stimpson) is closely covered with stout clavate or subcapitate spinelets stouter than any others immediately adjacent.

Adambulacral plates typically diplacanthid, except distally where they are alternately diplacanthid and monacanthid, or are mostly monacanthid. The spines are slender terete, with bluntly rounded tips. The inner or marginal is likely to be gently tapered, and slenderer than the outer, which is more often slightly clavate. The robustness of both varies with that of the general spinulation and is subject to considerable variation. There are two plates in contact on the interradial line external to the oral plates. The first if conspicuously larger than the second. About 23 or 24 plates correspond to the first 10 inferomarginals.

The oral plates are typical of *Leptasterias*, with one apical and one suboral spine to each plate, the former about as long as the median suture, but neither especially diagnostic. The apical spine is usually tapered. Verrill (1914, p. 149, fig. 7*a*) figures the mouth plates with two apical spines each, one behind the other. This is an artist's mistake, as I have been unable to find such an arrangement in any of my specimens, including four from the same locality at which Verrill's example was taken (between Icy Cape and Cape Lisburne). The spine marked *a* is the suboral, while that labeled *e* is the first subambulacral.

Abactinal papulae are arranged in irregular transverse rows between the transversely arranged groups of spines. There is a longitudinal supramarginal series, an intermarginal, and an actinal, the latter extending about half the length of the ray. Although the marginal and abactinal areas are large there are relatively few papulae to an area—one to three in the intermarginals.

Large straight pedicellariae occur very sparingly in the intermarginal channel and in the actinal interradial channels, and occasionally on the lateral portions of the abactinal area. These are compressed and thin, lanceolate, acute, as seen from the side, and the jaws are narrow as viewed from the back. The tips are curved or bent, and crossed; or one jaw is notched for the acute opposing jaw. This type is found in large specimens, and, if at all in small ones, in the axillary channels only. Rarely the jaw is tridentate. The largest of these pedicellariae measure 0.8 to 1.2 mm. Smaller but similarly formed ones are found in clusters on the oral, and less often on the proximal furrow spines; and still smaller ones, on the furrow face of the adambulacral plates.

Crossed pedicellariae of rather characteristic *Leptasterias* form are spaced, in circles, around the abactinal spines, and form dense wreaths encircling the marginal and actinal spines (not half-wreaths), and clusters on the outer side of the adambulacral spines. In some specimens the furrow spines are practically without pedicellariae (station 3252) while in others from the same locality small clusters are present. In alcoholic specimens the pedicellariae are much more conspicuous than in dried examples, and the marginal clusters are often in contact, especially distally. When the abactinal spines are very small, as they sometimes are, especially in small arctic examples, they are difficult to differentiate from the pedicellariae, so that the abactinal surface has the appearance of being covered with a multitude of small spinelets, as in *Henricia*. The dorsal pedicellariae of large examples measure 0.21 or 0.22 mm. (station 3252) to 0.25 mm. (station 3506).

Madreporic body fairly large, a little more than one-half r from center, and partly or completely encircled by spinelets.

Variations.—The extremes of variation include an arrangement of the abactinal spinelets characteristic of *Leptasterias cribraria* on the one hand and of *L. groenlandica* on the other. There are numerous specimens which if considered as isolated cases, might be classified as aberrant examples of either *cribraria* or of *groenlandica*. These are the intermediates.

Forma CRIBRARIA (Stimpson)

Plate 8, Figures 1, 1*a*, 1*d*, 2, 2*a*; Plate 21, Figures 1,2, 4; Plate 22, Figures 3, 4, 5; Plate 24, Figure 2

The chief variations of forma *cribraria* (*spitzbergensis*) concern chiefly the size, number, and spacing of the abactinal spinelets, and the relative numbers of them which are slender, clavate, or subcapitate; the robustness of the abactinal plates, and the spacing of the transverse ridges (for instance the number in the proximal half of the ray); the number of superomarginal spines; the robustness of the marginal and actinal spines; the abundance of pedicellariae, both crossed and straight.

The conditions of the abactinal area affect the general appearance more profoundly than variations of other parts of the body. A decrease in the number of spinelets is generally accompanied by an increase in their size. A specimen from station 3252 with R 54 mm. (pl. 21, figs. 1, 2), has very small spinelets of diverse caliber, usually strongly clavate and 0.4 or 0.5 mm. long. Twenty or twenty-five can be counted across the ray near the base. This example would be classed as typical *cribraria*. A specimen of precisely the same size from station 3506 has the spinelets about twice as robust—especially in the middle third of the transverse line—and there are about 10 to 15 between the two superomarginal series, near the base of ray. This might be classified as an aberrant *groenlandica*, but is rather more like *cribraria*, although the spinelets are too thick. A cleaned specimen from this station shows that the skeleton is much stouter than usual, and as a result the skeletal meshes are narrower. In a somewhat similar specimen from station 3522 (pl. 22, fig. 3) the spinelets are upwards of 1 mm. long mostly, subcapitate or heavily clavate, and two or three times thicker than in typical specimens. From station 3420, an example with R 50 mm. has the spinelets mostly cylindrical, or else a trifle clavate in the carinal series, about 0.75 mm. long, and well spaced, so that there are about 10 across the ray near base. These spinelets are in transverse series but they are not so small, so numerous, nor so close together as in typical *cribraria*. There is also an indication of longitudinal series; a considerable number of the supero and infero marginal plates are monacanthid, and the adambulacral plates are irregularly monacanthid and diplacanthid. This specimen, if considered alone, would be classified, hardly without question, as *L. groenlandica*.

One feature which is common to slender spined and stout spined forma *cribraria* and to the various modifications of forma *groenlandica* is the structure of the dorsolateral skeleton, in which the transverse trabeculae are dominant, and leave a series of short but very wide papular areas. These areas are as well developed in a typical specimen of *groenlandica* from the north of Asia (Stanford collection, No. 10, pl. 23, fig. 1) as in typical *cribraria* from Bering Sea, many of them reaching from the carinal to the superomarginal series of plates.

Forma GROENLANDICA (Lütken)

Plate 8, Figure 1*b*, 1*c*, 2*b*, 3; Plate 21, Figure 3; Plate 22, Figure 1, 2; Plate 23; Plate 24, Figure 1

Forma *groenlandica* differs from *cribraria* chiefly in having fewer, larger, and more widely spaced abactinal spinelets, which as a consequence do not show such an obvious and definite arrangement in consecutive transverse combs. However, as there are all sorts of intergrades it is difficult to lay down any definite rule. An example of forma *groenlandica* from station 3485 has the abactinal spines in definite longiseries about 9 or 10 at the base of ray, and also in definite transverse series. There are usually only one or two superomarginal spines, while in *cribraria* there are three, or even four, and in some but not all examples there are irregularly one and two adambulacral spines. I can not find any constant difference in either sort of pedicellariae.

I have no theory to offer in explanation of the wide variation in the species. It is strange, in view of the fact that the young are carried by the mother, that there have not been developed in various parts of the circumpolar range—especially on the southern margin—well marked local races. But the specimens from Bering Sea exhibit pretty much the entire gamut of structural variations. Both formae are found in the Arctic Ocean. Among the large number of specimens from station 3252, Bering Sea, all the largest examples are referable to forma *cribraria*—that is, all having R over 30 mm., while about half of the small examples are forma *groenlandica* or intermediate. In the list of specimens the forma found at each station is marked—*c* for cribraria, *g* for groenlandica, and *i* for intermediate or "indifferent" forms.

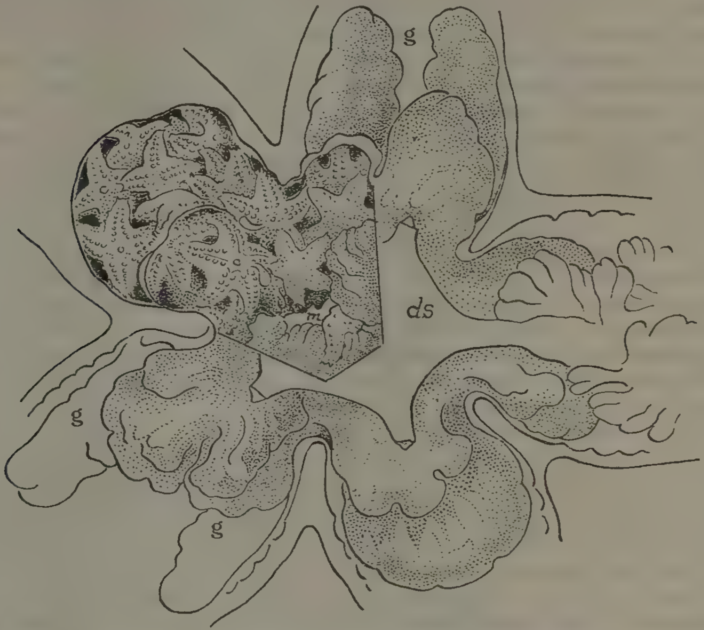

FIGURE 2.—LEPTASTERIAS GROENLANDICA SHOWING THE STOMACH FULL OF YOUNG READY TO ESCAPE. THE DORSAL WALL OF BODY AND PART OF THAT OF THE STOMACH HAVE BEEN REMOVED TO SHOW THE VENTRAL STOMACH, WHICH HAS BEEN CONVERTED INTO A BROOD CHAMBER. THE FULLY DEVELOPED YOUNG ARE SHOWN IN SITU; *ds*, DORSAL STOMACH; *g*, GONADS; *m*, MOUTH, SEEN LOOKING VENTRALLY THROUGH STOMACH; ABOVE THE MOUTH IS SHOWN THE FOLD SEPARATING THE DORSAL FROM VENTRAL STOMACHS. ×3

There is a very characteristic feature of Bering Sea examples as compared with those from Greenland, Spitzbergen, and Kara Sea. The former generally have conspicuous clusters of pedicellariae on the outer adambulacral spines, and frequently also smaller clusters on the furrow spines, although these may occur sporadically when the outer spines are well armed. Rather often both sets are swell provided with pedicellariae which do not differ essentially from the abactinal crossed pedicellariae, though sometimes a little larger. This characteristic seems correlated with a somewhat greater abundance of pedicellariae elsewhere on the body.

In Greenland, Spitzbergen, and Kara Sea small examples the adambulacral spines normally lack pedicellariae (where in Bering Sea specimens the outer spines would have small clusters). In large specimens the outer spine of diplacanthid plates may carry a conspicuous cluster of pedicellariae, but not the furrow spine. Only a few specimens are large however; most of them lack adambulacral spine pedicellariae, except sporadically.

A considerable number of dwarf specimens are among those recorded in the list of localities, especially from Indian Point, Bering Strait (3582), Bering Strait (16591), and Plover Bay, 10 to 25 fathoms (16584). Duplicate specimens of the last two lots were examined by Verrill and are recorded (1914, p. 123) as *L. arctica*. The Plover Bay specimens are in poor condition. They are all small, with tumid rays and numerous short spinelets. Some of them carry eggs in the stomach, a habit so far as known, not characteristic of *arctica*. The adambulacral plates are mostly diplacanthid, and the marginal spines have complete rings of pedicellariae. The smallest specimen known to be carrying eggs has R only 12.5 mm., r 6 mm.

Young.—Very small specimens have that generalized appearance which renders identification, in the absence of adults, extremely unreliable. It is difficult, in a species which breeds when small (R 12.5 mm.) to differentiate between real young and dwarfed specimens. There is a very real difference, in that the dwarfed specimens have more spines. They remind one of dwarfed trees that have managed to add new rings without much increase in size. Such are numerous small examples (some carrying eggs) from Plover Bay, Siberia, and two examples from Indian Point, Bering Strait, 17 fathoms (No. 3582), the largest of which has R only 13 mm., but which resembles an adult of forma *cribraria* in miniature.

Undoubted young, with R 7 mm., have a 4-faced ray, with gently convex abactinal surface. The abactinal spinelets, five or six across the abactinal area, already are arranged in transverse rows, with a pretty definite longitudinal arrangement, in about five series, in those specimens which are probably destined to become forma *groenlandica* (station 3252). Of crossed pedicellariae there are a few abactinally and a circle around the marginal spines; and of the straight a few along the edge of the furrow. There is one series of superomarginal, one of inferomarginal, and two of adambulacral spines. The abactinal plates, relative to width of ray, are very large and the papular areas small. A specimen with R 14 mm. has eight or nine spinelets across the ray near base, two inferomarginals on distal half of ray, one to five crossed pedicellariae to each abactinal spine, and fairly well developed marginal wreaths. The abactinal spines are quite regular, but I think the specimen was destined to become forma *cribraria*. A breeding specimen of the same size (forma *groenlandica*) from Bering Strait (No. 16591) differs in having complete circles of crossed pedicellariae around the abactinal spinelets, mostly two superomarginal and two inferomarginal spines with thick wreaths of pedicellariae, and large straight pedicellariae on the axils of the rays.

Anatomical notes:—As mentioned under variations there is a good deal of individual difference in the abactinal skeleton which is of the very open, irregularly reticulate type, characterized by slender plates and on the rays by unusually short but broad meshes, one to three of which intervene between the carinal and superomarginal series. The details are scarcely twice alike. The carinal plates are three or four lobed and form a zigzag or sinuous series. The superomarginals and inferomarginals are rather regularly four lobed, with longer dorsoventral than longitudinal lobes. The dorsolateral skeleton is composed of irregular plates, rodlike, oblong, spatulate, straight, bent, or irregularly three lobed, but with the long axis transverse to the ray, except in the case of a few connecting plates between the consecutive costae. In the thickness of these plates there is a difference of fully 100 per cent between specimens from station 3252 and 3506, those from the latter having a heavy skeleton with smaller meshes.

The skeleton is not basically unlike that of other species, and certainly not greatly unlike that of *L. mülleri* the type of the genus. The development of large dorsolateral papular areas or meshes in the skeletal reticulum must be regarded rather as specific than generic, and is associated with the mostly transverse dorsolateral ossicles, which Verrill believed to be of generic importance (*Ctenasterias*).

Internal anatomy.—The testes have the usual *Leptasterias* form, and when fully developed fill most of the coelomic cavity of the disk and rays, impinging upon the stomach, and occupying all available space between the dorsal and ventral divisions. They press the hepatic coeca against the dorsal body wall, and reach three-fourths the length of ray measured on side. Each is roughly spindle-shaped, and consists of a central canal or axis, from which branch off a number of very irregularly lobulated major divisions (usually toward the mesial line of ray) and numerous very irregular, subdivided, small lobes which fill in pretty much all the available space. The duct passes downward about opposite the first superomarginal plate, and opens by a papilla, on the actinal surface, close to the interradial line. There are usually, here, one to three large lanceolate straight pedicellariae. The duct has ciliated epithelial lining (Lieberkind).

The ovaries are very similar to those of other species of *Leptasterias*, as, *arctica*. They were found to be full of large and small oocytes at the same time that the young, nearly ready to shift for themselves, were still being carried by the mother.

Lieberkind found a specimen with nine ovaries, while the tip of the tenth was hermaphroditic, the eggs lying along the wall and the spermatozoa in the middle. (1920, fig. 4, p. 125.)

The stomach is of the usual form, and very spacious in the female by whom it is used as a brood pouch. The intestinal coecum is rather triangular in general form with three thick lobes radiating from the base, the whole about one half r in length. The hepatic coeca are large and extend well toward the extremity of the ray.

Care of the young.[14]—The eggs after emerging from the oviducts, which open ventrally as in other species of *Leptasterias*, are probably kept for a short time under the disk. It is usual for species of *Leptasterias* to form a temporary nursery by drawing the rays together and raising the disk. Fertilization probably takes place while the eggs are here. They are then taken into the stomach, where development ensues. Specimens from Plover Bay, with short tumid rays and with R only 12.5 mm., are already carrying eggs in the stomach (No. 16584). These eggs are relatively very large, measuring 0.8 to 1 mm. in diameter.

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[14] Lieberkind, On a Starfish (*Asterias groenlandica*) Which Hatches its Young in its Stomach. Saertryk af Vidensk. Medd. Fra Dansk. naturh. Foren., vol. 72, p. 122, fig. 1, November, 1920.

In all of the other specimens at my disposal (stations 3251, 3252, 3506, 3541, Bering Strait, No. 6591) the young have reached an advanced stage. As Lieberkind writes, it is the ventral, eversible stomach which is used as a brood pouch. The number of young is in proportion to the size of the adult. In a specimen with R 43 mm., 42 young were counted but in the specimen figured (R 47 mm.) there were probably 100, although they were not disturbed, or counted. As the egg develops it naturally increases in size until the stomach becomes greatly distended, and the walls in preserved specimens are quite thin. The young are crowded into the radial pouches, and are found also in the central portion over the mouth. I did not find them in the dorsal stomach, which confirms Lieberkind's observations, although "at times the number of the eggs or the young was so great that they protruded through the opening between the lower and upper part, forming a plug in the opening (perhaps, however, this may be due to contraction on preservation).[15]

The young are frequently oriented with the actinal side against the stomach wall and in some cases they may be seen through the tissue. In all the specimens except that from Bering Strait, the young are separated—that is, are not joined to a central mass of tissue as figured for *L. arctica*. The larval organ, as a lappet of tissue, is still conspicuous, and arises from an interradius back of the mouth plates. In the Bering Strait specimen (No. 6591) however the young are not quite so advanced, and are anchored by a strand of tissue to a central mass, much as in *L. arctica*.

In this case nearly half the young are outside the mouth, and the disk seems to be arched in a natural manner as if to form an external brood chamber. This specimen is small (R 16 mm.) and it seems likely that it swallowed more eggs than there was subsequently room for after complete development. Most of the large specimens, known to be carrying young, have a few around the actinostome, although it is possible these were expelled by contraction of the rays during preservation, especially as the stomach in a few cases is partly extruded.

I think however that during the later stages of development it is perfectly normal for the young to be extruded from the stomach. This might well take place for purposes of respiration, even if the actinal gastric space were sufficient to accommodate the increase in bulk due to growth. Possibly during the whole course of development the eggs and embryos are given a periodic "airing."

As stated above, specimens carrying young were taken at stations 3251, June 14, 1890, bottom temperature 37.5° F.; 3252, same date, bottom temperature 44.8° F. (probably an error); 3506, July 29, 1893, bottom temperature, 32° F.; 3541, August 10, 1893, bottom temperature 36.1° F.; and at Bering Strait, July 14, 1879. The breeding season extends probably from May through August. On June 14 the young are large enough to leave the mother. The recorded temperature ranges from 32° to 44.8°. The first is usually low and the second unusually high for the locality, judging by records of the preceding and succeeding soundings. (See list of stations.) Thirty-six and thirty-seven degrees are probably near the optimum for successful development.

My observations confirm those of Lieberkind in respect to the entire absence of food from the stomachs of all specimens carrying young.

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[15] Saertryk af Vidensk. Medd. Fra Dansk. naturh. Foren., vol. 72, p. 122.

What is there about the eggs and young that inhibits the secretion of digestive fluids?

Parasites.—Two specimens from station 3252 were found to be infected by the curious ascothoracid cirripede *Dendrogaster*—possibly *Dendrogaster astericola.*[16] In one specimen with R 40 mm. were three of the parasites, the most symmetrical of which, as seen from the side toward the actinal surface of the starfish, is shown in text Figure 3*a*. The branches occupied two rays. The second parasite was crowded into one ray, while the third occupied the disk and the two remaining rays. The gonads of this sea star, a male, were very poorly developed although in normal examples the testes are very large. In the other specimen there was only one *Dendrogaster*, but this was larger. (Text fig. 3.) The gonads in this starfish are partly normal, and partly retarded. Seven testes are normal or nearly normal, as marked "*g*." Those in the unoccupied ray seem to be quite as large as in unparasitized specimens. Two gonads (in positions marked "*g′*") are reduced in size, while the tenth (*g″*) is entirely absent, apparently because of the pressure exerted by a large lobe of the *Dendrogaster*. The stomach and hepatic coeca of this specimen are so crowded by the parasite that

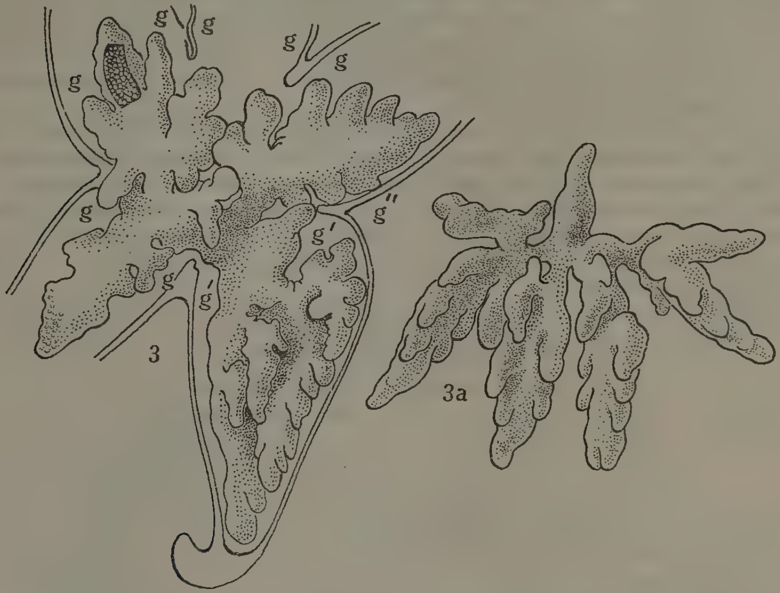

Figure 3.—A parasitic cirripede, Dendrogaster species, from a specimen of Leptasterias groenlandica station 3252; dorsal view, × 2; *g*, signifies normally developed gonad; *g′*, gonad reduced in size; *g″*, gonad absent. A portion of the body wall of parasite has been removed to show contained eggs. 3*a*. Ventral view of a dendrogaster from a specimen of L. groenlandica having three parasites, station 3252, × 2

it is difficult to understand how anything like normal feeding could have been carried on.

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[16] N. Knipowitsch, Révue des sciences nat., à St. Petersbourg, No. 8, 1890 (October), pp. 353-357. Summary p. 374. Beit. z. Kennt. Ascothoracida, Trans. Soc. Nat. Petersbourg, vol. 23, 1892, p. 134.

Of the four specimens of *Dendrogaster*, three are full of eggs, or very early embryos. The fourth (one of the three from a single host) contains myriads of *Cypris* larvae, rather poorly preserved. These were about ready to emerge. Presumably they reach the exterior through the papulae.

Type locality.—Greenland.

Distribution.—An arctic, circumpolar species. Von Hofsten (1915) gives a map, and summarizes the distribution as follows (p. 60): Spitzbergen; Siberian Ice-Sea to east of the New Siberian Islands; Kara Sea; Barents Sea; Murman Coast and White Sea; south, southeast, west and northwest coasts of Greenland; Ellesmere Land; Cumberland Gulf. East coast of North America: Labrador, Gulf of St. Lawrence, banks off Nova Scotia, Newfoundland, Bay of Fundy. He gives the bathymetrical distribution as from 5 to 150 meters.

A. H. Clark (1920) records the species from Bernard Harbor, Northwest Territories, 2 to 3 fathoms, and from west of Cockburn Point, Dolphin and Union Strait.

The specimens listed below range from the Arctic Ocean (Point Franklin and between Cape Lisburne and Icy Cape) to the southern part of Bering Sea (Bristol Bay and north of Unimak Island), and to Kamchatka. The bathymetrical range is from 7½ to 71 fathoms. Ludwig (1886) records the species from St. Matthew Island, and St. Laurence Bay, Siberia.

Specimens examined.—Three hundred and twenty-nine. The letters signify: *c*, forma *cribraria; g*, forma *groenlandica; i*, intermediates.

Specimens of Leptasterias groenlandica examined

Station	Locality	Depth	Nature of bottom	Bottom temperature	Number of specimens	Remarks
		Fathoms		°*F.*		
3251	Bering Sea, 57° 35′ 50″ N., 164° 05′ W	25.5	Fine gray sand	37.5	*c i* 3	U.S.N.M.
3252	Bering Sea, 57° 22′ 20″ N., 164° 24′ 40″ W	29.5	Black mud	44.8	*c g i* 128	U.S.N.M. (carrying young).
3253	Bering Sea, 57° 05′ 50″ N., 164° 27′ 15″ W	36	Mud, sand	35	*c g* 2	U.S.N.M.
3254	Bering Sea, 56° 50′ N., 164° 27′ 50″ W	46	Green mud, sand	36.2	*i* 1	Do.
3255	Bering Sea, 56° 33′ 30″ N., 164° 31′ 40″ W	43	do	37	*c g* 6	Do.
3256	Bering Sea, 56° 18′ N., 164° 34′ 10″ W	49	Green mud, black shells	35	*g i* 2	Do.
3309	Bering Sea, 56° 56′ N., 172° 55′ W	71	Green mud	37.9	*g* 2	Do.
3485	Bering Sea, 57° 18′ N., 172° 34″ W	62	do	37.1	*g* 1	Do.
3506	Bering Sea, 57° 33′ N., 165° 55′ W	36	Gray sand, mud	32	*c g i* 12	U.S.N.M. (carrying young).
3507	Bering Sea, 57° 43′ W., 164° 42′ N	31	Fine gray sand	37.5	*c* 1	U.S.N.M.
3520	Bering Sea, 59° 28′ N., 170° 57′ W	38	Green mud, fine sand	32.2	*g* 1	Do.
3522	Bering Sea, 57° 58′ N., 170° 09′ W	41	Coarse gray sand, gravel	35.7	*c* 2	Do.
3529	Bering Sea, 58° 36′ N., 172° 24′ W	56	Green mud	36.1	*c g* 2	Do.
3530	Bering Sea, 59° 39′ N., 173° 53′ W	59	Dark green mud, fine sand	34.9	*g* 3	Do.
3531	Bering Sea, 59° 55′ N., 174° 17′ W	59	Green mud	35.1	*g* 2	Do.
3537	Bering Sea, 54° 45′ N., 169° 06′ W	49	Fine gray sand	38	*g* 2	Do.
3541	Bering Sea, 56° 14′ N., 164° 08′ W	49	Black mud, fine sand	36.1	*c i* 16	U.S.N.M. (carrying young).
3542	Bering Sea, mouth Bristol Bay	49	Dark mud, fine sand	39.2	*c* 1	U.S.N.M.
	Point Franklin, Arctic Ocean	13.5	Sand		*c* 12	Aug. 31, 83; part No. 7625, with *L. arctica*.

Specimens of Leptasterias groenlandica examined—Continued

Station	Locality	Depth	Nature of bottom	Bottom temperature	Number of specimens	Remarks
		Fathoms		° *F.*		
	Between Icy Cape and Cape Lisburne	15–18	Mud and sand		[e] 4	W. H. Dall, 1213, 1214 (6123).
	Arctic Ocean				[e] 4	
	Do				[g] 1	North Pacific expedition, Captain Rodgers, No. 1362.
	Do				[c] 3	North Pacific expedition, No. 1349.
	Off Point Clarence, Alaska	7.5	Pebbles		[c] 1	No. 7628, Point Barrow expedition.
	Arctic Ocean				[c] 1	6905, U.S.R.S. Corwin, 1880.
	Indian Point, Bering Strait	17	Gravel		[e] 2	W. H. Dall, 1830, 3582 (657).
	Bering Strait				[g] 1	Wm. Stimpson, 1357.
	Do.[1]				[i] [g] 9	Dr. Robt. White, July 14, 1879 (1659) small, 2 with embryos in stomach.
	Plover Bay, Siberia	15–20	Rocky		8	3576 (part).
	Do.[1]	10–25			10	W. H. Dall, 3808 (1720) 16584.
	Awataka Bay, Kamchatka				1	No. 1328, North Pacific expedition, Captain Rodgers (1 arm only).
	Northwest of Bering Strait, 66° 58′ N., 171° 35′ W.	21	Mud and clay		[g] 2	Stanford Coll.
56	71° 39′ N., 157° 15′ W	10	Brown Clay		[g] 1	Riksmuseum, Stockholm, Vega exp.
	67° 07′ N., 173° 24′ E., Vega's winter harbor, Pitlekai.				[c] [g] 2	Do.
1006	Just north of Vega's winter harbor	15	Stones with clay		[c] 1	Do.
1042	66° 58′ N., 171° 35′ W	21	Sand, a little clayish		[c] 2	Do.
	Port Clarence, Alaska	4–6	Stones		1	Do.
1053	65° 14′ N., 168° 35″ W	29	Sand, small stones		[i] 1	Do.
1054	65° 10′ N., 169° 50′ W	25	Mud		[i] 1	Do.
1068	62° 39′ N., 177° 05′ W	55	Clay		[c] [g] [i] 4	Do.
	Greenland, Godhavn	15–60			[c] 11	Riksmuseum, Stockholm, Amundsen.
	Greenland, Egeden Minde	15–30			[g] 1	Riksmuseum, Stockholm, O. Tarrell.
	Greenland, northwest of Cape York	15–15			5	Riksmuseum, Stockholm, Sofia exp.
	Kara Sea, 71° 54′ N., 67° 37′ E	21			11	Riksmuseum, Stockholm, Nova Zembla expedition.
	Jugor Strait, off Kara Sea	5–8	Mud, stones		15	Riksmuseum, Stockholm, Vega exp.
	Spitzbergen, Shoal Point	25–30			4	Riksmuseum, Stockholm, Spitzbergen expedition, 1861.
	Spitzbergen, Treurenberg Bay	6–30	Stones		6	Do.
44	Preobraschenije Island, mouth of Khatanga Bay, Siberia (113° 30′ E. long).	5	do		19	Riksmuseum, Stockholm, Vega exp.

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[1] Recorded by Verrill (1914) as *L. arctica*, p. 123.

Remarks.—I have not been successful in discovering any constant characters[17] by which Stimpson's *cribraria* can be separated from the earlier *groenlandica* of Lütken or the later *spitzbergensis* of Danielssen and Koren. The last two species are considered the same by Döderlein,[18] Grieg,[19] and von Hofsten (1915, p. 59). Verrill at first united *groenlandica* and *cribraria* (1909, p. 553) but later (1914) kept them separate. In the latter work he compares *cribraria* with *spitzbergensis* and concludes that they are "identical but variable." Professor Verrill's material was not abundant, much of it consisting of depauperate and young specimens. With a large series at his disposal I feel sure that he would have adhered to his first decision.

Mortensen at first considered *mülleri* and *groenlandica* to be varieties of the same species. He says:[20] "Though a typical *A. groenlandica* as to habitus differs very much from a typical *A. mülleri*, especially of the var. *islandica* Levinsen, there is evidently not a single character to be relied upon by which they may be distinguished. I think we must then conclude that they can not be maintained as two distinct species. The form *groenlandica* must be regarded as a more or less distinct variety of *A. mülleri*." In his latest publication, however, he definitely separates the two species.[21]

Von Hofsten (1915, p. 59) adopts a middle course and classifies *groenlandica* as an arctic subspecies of the boreal *mülleri*.

Light is thrown upon the question by a comparison of breeding habits. According to Sars,[22] *L. mülleri* broods its young under the disk in a cavity formed by the rays. In *groenlandica* the eggs and developing young are carried in the stomach. It is inconceivable that the same species would develop two such fundamentally different modes of caring for the young.

L. arctica, the Bering Sea equivalent of *mülleri*, is perfectly distinct in every way from *L. groenlandica*.

Leptasterias obtecta Verrill (1914, p. 144) is referable to *groenlandica*. I have examined the type, No. 1208, Museum of Comparative Zoölogy, 12 miles east of King's Island, Bering Sea, 17 fathoms. The specimen is characterized by slender spinelets very numerous crossed pedicellariae, and smaller than typical dorsolateral papular areas. The skeleton of one ray was cleaned. It is not essentially different from forma *cribraria* with the exception that on the proximal two-thirds of the ray the transversely elongated papular areas adjacent to superomarginal plates are not so broad as is usually the case in *cribraria*. Between the mesial ends of these meshes and the irregular series of carinal plates are one or two irregular, very distinctly smaller, papular areas. The supramarginal skeletal meshes are therefore larger than the others and wider than long in most cases. The adambulacral plates of the proximal half of ray are diplacanthid; those of the distal half alternately monacanthid and diplacanthid. The Henricia-like appearance of the dorsal surface is due to the numerous crossed pedicellariae which on account of the slenderness of the abactinal spinelets appear to be relatively larger than they actually are when compared directly with pedicellariae of typical forma *cribraria*. A pedicellaria attached to a slender spinelet has the appearance of being larger than when attached to a spinelet 50 to 100 per cent thicker.

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[17] The only tangible difference is that of the adambulacral spine pedicellariae of both forma *cribraria* and forma *groenlandica* of the Bering Sea region, as noted under Variations. In large Greenland examples these pedicellariae are present, and they are sometimes very scanty in small Bering Sea examples.

[18] Die Echinodermen der Olga Expedition. Wiss. Meeresunt, new ser., vol. 4, Abt. Helgol. 1900.

[19] Report of the Second Norwegian Arctic Expedition in the "Fram" 1898-1902. No. 13 Echinodermata, 1907, p. 13.

[20] Echinoderms from East Greenland, Meddel. om Grønland, vol. 29, 1903, p. 70.

[21] Echinoderms of the British Isles, 1927, p. 143.

[22] Fauna littoralis Norvegiae, 1 Lief., 1846, p. 58. Mortensen Echinoderms of the British Isles, 1927, p. 142.

LEPTASTERIAS OCHOTENSIS (Brandt)

Plate 12; Plate 27; Plate 28

Asteracanthium ochotense Brandt, Middendorff's Reise in den äussersten Norden und Osten Sibiriens, vol. 2, pt. 2, 1851, p. 28. (Also var. *macrobrachia* and var. *brachybrachia*.)
Asterias ochotensis Perrier, Pédicellaires, 1869.
Leptasterias ochotensis Fisher, Bull. U. S. Nat. Mus., 76, pt. 2, 1928, p. 1.

The specimens upon which the following account is based are a part of Brandt's original material. Doctor Mortensen kindly loaned a dried example received by the Copenhagen Museum in 1871 and furnished photographs of another specimen representing Brandt's variety "*macrobrachia*." (Pl. 28, figs. 2, 3.) Later, Dr. A. Djakonov, of the Academy of Sciences, Leningrad, sent four specimens in alcohol which are of particular value, since it is possible to determine that the gonads open ventrally. The largest of these examples in size and detail is closely similar to Plate 28, Figure 2. Doctor Djakonov writes that the museum possesses two jars with many alcoholic specimens and some dried ones all labeled by Brandt himself. No actual type appears to have been indicated. I am especially indebted to Doctor Djakonov for the donation of this material, which is now in the United States National Museum. Aside from its scientific value it possesses great historic interest for anyone concerned with the zoology of the north Pacific.

Diagnosis.—Rays five; R 40 mm., r 9 mm. R=4.4 r. (R=3⅓ to 5 r, Brandt); breadth of ray at base, 10–11 mm. Abactinal spines small; well-spaced, cylindrical or clavate (with a differentiated irregular carinal series) interspersed with abundant triangular straight pedicellariae; ray normally rounded, the marginals close together and lateral in position; a single series of superomarginal (proximally sometimes two), inferomarginal, and actinal spines larger than the abactinals, and forming a bristling lateral and ventrolateral armature; superomarginal and inferomarginal plates of adult specimens connected in series by a smaller intermediate ossicle; adambulacral plates with proximally two, then one (or with alternately one and two) spines; abundant lateral and actinal straight pedicellariae.

Description.—The abactinal surface of the disk and rays is beset with small cylindrical or clavate, minutely thorny and usually terminally grooved spinelets of divers sizes, varying from about 0.5 to 0.7 mm. in length by 0.3 to 0.4 mm. in breadth. Smaller spinelets measuring 0.35 to 0.5 mm. long by about 0.1 mm. in thickness are much less numerous, and are found toward the end of the ray, or one or two may accompany the coarse spinelets. (Pl. 12, figs. 3 and 4.) The spines are fairly well spaced, varying in this respect as shown by the figures, and the carinal series is differentiated as an irregular line. As in most forms of *Leptasterias* the dorsal spines increase in length from the carinals toward the superomarginals.

Abactinal skeleton (pl. 12, fig. 9) an irregular, open, reticulum, the primary irregularly three and four lobed plates being connected by elongate intermediate ossicles.

Superomarginal series turns upward near base of ray reaching the abactinal end of the interbrachial or axillary sinus; beyond middle of ray intermarginal channel is narrow. Except sometimes at base of ray, most of the superomarginals alternate with a secondary ossicle (pl. 12, fig. 9) which persists for about three-fourths the length of ray. A similar ossicle is present, but less regularly, between the inferomarginal plates. They are present probably only in fully adult animals since none are present in a specimen with R 27 mm.

There is generally but one superomarginal spine to a plate, cylindrical and slightly tapered, of the general form of the slenderer inferomarginal spines, but a little shorter. There is a single series of stout inferomarginal spines, decidedly more robust than the superomarginals, and a single series of similar actinal spines which extends about half the length of the ray. The spines of these two series are 1.5 to 1.6 mm. long, robust, cylindrical, slightly tapered as a rule, and round-tipped.

The adambulacral plates are diplacanthid at the base of the ray, then monacanthid but with the spine alternately on the furrow margin and set slightly back. In the largest specimen sent by Doctor Djakonov the spines alternate fairly regularly one and two as described by Brandt (R 40 mm.). The spines are about 1.5 mm. long, slender, terete, round-tipped, sometimes slightly tapered. The first and second pairs of adambulacral plates are in contact interradially, or the second pair simply touch; the first plate is conspicuously longer than the second. The first three are monacanthid.

The mouth plates are rather short and broad, the length of the median suture being less than that of the first two pairs of adambulacrals. There are two apical and one suboral spine, the latter a little longer and stouter than the first few adambulacral spines. (Pl. 12, fig. 10.)

Straight pedicellariae of a characteristic subtriangular form are very abundant among the abactinal spines, in the intermarginal furrow, actinally, and along the furrow face of the adambulacral plates. They are less numerous on the oral and adambulacral spines. The abactinal vary in size from 0.22 to 0.4 mm. in length and occur on the surface of the plates between the spines, the largest being in the neighborhood of the marginal plates. The lateral (intermarginal) are 0.5 or 0.6 mm. long, while the largest axial ones are 0.7 mm. long by 0.5 mm. broad at the base. The adambulacral are 0.25 to 0.3 mm., and the largest oral 0.4 and 0.5 mm. long. (Pl. 12, figs, 5, 6, 7.)

Crossed pedicellariae occur in circles around the dorsal and superomarginal spines, and in clusters on the outer side of the inferomarginal, actinal, and adambulacral spines. They are apparently not very abundant abactinally. The abactinal pedicellariae are 0.22 to 0.25 mm. long, the terminal toothed part being about 0.055 to 0.08 mm. long. The adambulacral are 0.26 to 0.28 mm. long, while the terminal toothed part, in profile, is 0.12 to 0.15 mm. long. The difference in the two sorts is shown on Plate 12, figures 1 and 2.

Madreporic plate convex, surrounded by a circle of spines, and located at mid r. The striae are coarse and irregular.

Papulae few to an area, and similar to those of other small *Leptasterias*.

The ovaries of the specimen examined are compact, with subglobose lobules containing relatively large ova. The duct is attached to the interbrachial septum on a level with the nearest inferomarginal plate. It passes between two dorsolaterally oriented plates of the septum, turns abruptly downward and can be followed to the ventral integument. With the specimen under water and in sunlight the external aperture is readily demonstrated. In each interradius two apertures lie close together near the outer end of the third adambulacral, consequently in the narrow angle just external to the adoral carina. Near the apertures are several conspicuous straight pedicellariae, such as Plate 12, Figure 5.

Color in life.—The dorsal surface varies from dirty bluish red, or reddish brown with orange to yellow-brown-red and sometimes even green to dull grass green. Actinal surface always vermilion, the tube-feet flesh color (Brandt).

Type.—Brandt's material is in the Museum of the Academy of Sciences, Leningrad.

Type locality.—Okhotsk Sea (Shantar Islands, Tugur Bay, Achae Island; Mamtscha Bay).

Distribution.—Okhotsk Sea.

Specimens examined.—A dried specimen labeled Mamtscha Bay, Zoological Museum, Copenhagen. (Pl. 27.)

Four alcoholic specimens determined by Brandt, labeled "Mare Ochotense, Coll. Middendorf" (Museum Acad. Sci. U. R. S. S. Nos. 1327, 1354).

Remarks.—So far as known this species is confined to the Sea of Okhotsk. However, H. L. Clark has described a very similar form, *Asterias similispinis* [23] from Taraku Island, near Nemuro, Hokkaido. I have examined one of the six original specimens (No. 1964, Mus. Comp. Zoöl.), the largest of which has R only 25 mm. (R = 5 r). In the available specimen (R 22 mm.) the secondary marginal ossicles are not present. Neither are they present in small *ochotensis*. The rays are a little more robust than in *ochotensis* of similar size and the straight pedicellariae average smaller but are of the same triangular shape. Most of the marginal and actinal plates carry one spine. The gonads, although dried, indicate that the species is a *Leptasterias*.

Until a good series of Clark's species can be examined and its status definitely determined, I suggest calling it *Leptasterias ochotensis similispinis*.

Subgenus HEXASTERIAS, new

Leptasterias polaris group; symmetry hexamerous; size small or large. Type *Leptasterias polaris* (Müller and Troschel) Fisher. North Pacific, Arctic, North Atlantic.

Includes the following species: *aequalis* (Stimpson), *alaskensis* (Verrill), *alaskensis asiatica* Fisher, *alaskensis multispina* Fisher, *aleutica* Fisher, *asteira* Fisher, *camtschatica* (Brandt), *camtschatica dispar* Verrill, *coei* Verrill, *coei truculenta* Fisher, *hexactis* (Stimpson), *hexactis vancouveri* (Perrier), *leptodoma* Fisher, *polaris* (Müller and Troschel), *polaris acervata* (Stimpson), *polaris katherinae* (Gray), *polaris borealis* (Perrier), *pusilla* Fisher.

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[23] Bull. Mus. Comp. Zoöl., vol. 51, No. 11, 1908, p. 288.

POLARIS SECTION

LEPTASTERIAS POLARIS (Müller and Troschel)

Plate 30, Figures 1, 1*a*–1*c*, 2, 2*a*–2*d*; Plate 32, Figures 3, 3*a*; Plate 35

Asteracanthion polaris Müller and Troschel, System der Asteriden, 1842, p. 16.
Asterias polaris Stimpson, Proc. Boston Soc. Nat. Hist., vol, 8, 1862, p. 271.
Leptasterias polaris Fisher, Ann. and Mag. Nat. Hist., ser. 8, vol. 12, 1923, p. 599.

On the Atlantic side of North America *Leptasterias polaris* ranges from Disco Island, on the west coast of Greenland, south to the Gulf of St. Lawrence (Anticosti Island and Gaspé Peninsula), and the fishing banks off Nova Scotia. It extends into Hudson Bay. Although no specimens have been taken between Hudson Bay and a point east of Cape Lisburne, Alaska, there can be little doubt regarding the continuity of its range.

In the Arctic Ocean north of Bering Strait, in Bering Sea, and in the north Pacific just south of the Alaska Peninsula, a polymorphic race of *polaris* is in an extreme state of flux. It is represented by at least three well-marked forms, two of which have been described as distinct species. This race is *L. polaris acervata*, which takes its name from the earliest described of its formae. We appear to have here three species in the process of evolution. *L. katherinae* Gray, from the mouth of the Columbia and Straits of Georgia, is a more stabilized form apparently derived from the ancestors of the Bering Sea complex. It greatly resembles *L. polaris borealis* (Perrier) of Labrador. These two races are not genetically so close as their similarity would indicate, if they are each marginal differentiations, geographically widely separated, of an arctic and sub-arctic species (*polaris-acervata*). A possible alternative explanation would be that *L. polaris katherinae* and *L. polaris borealis* represent isolated segments of a preglacial species having a continuous distribution by way of a formerly warmer Arctic Ocean. With the advent of a colder era the arctic segment of the species became changed, leaving less modified and nearer the ancestral form that portion of the species which dwells in the warmer waters of either side of the continent.

L. katherinae is apparently nearest to forma *aphelonota*, the only one of the three phases of *L. polaris acervata* to be found at the south of the Alaska Peninsula. Elsewhere I have mentioned the possible duplicate origin of the specimens classified in this forma. Typical *aphelonota* may represent a geographic race, an offshoot of *acervata* to the south of the Alaskan Peninsula.

L. coei Verrill is probably an ancient derivative of *polaris* stock. Indeed, one may go further and assign a common origin to all the North Pacific 6-rayed species of *Leptasterias*.

Since the type specimen of *Asteracanthion polaris* Müller and Troschel came from Greenland, the Greenland race is naturally the substructure for taxonomic elaboration. There are two fairly well-marked formae of this race: One, forma *polaris*, has the spinelets fairly uniform in length, without evident aggregation into convex groups. Sometimes the spinelets are fairly well spaced; sometimes crowded. In the other and apparently less common variety, forma *subacervata*, new forma, there are a variable number of convex groups of somewhat enlarged spines. This is the biological equivalent, in *polaris*, of forma *acervata* in *L. acervata*. Similarly forma *polaris* is an equivalent of *aphelonota*. Both *subacervata* and *polaris* are present among Disco Island specimens.

For purposes of geographic analysis, Perrier's *Asterias borealis* from Caribou Island, Labrador (pl. 35, fig. 3), can be retained to designate the southern race of Atlantic *polaris*. Perrier's specimen was derived from the Museum of Comparative Zoölogy, which still possesses topotypes (No. 1307). It is doubtful, however, if this race is of any practical value, for its differentiation is based upon slight differences in pedicellariae. In the crossed pedicellariae as seen from the side (pl. 30, figs, 2, 2a–2d) the terminal lip does not extend so far down on the shank in the southern as in northern examples. A similar latitudinal variation is apparent in *L. polaris acervata* and *L. polaris katherinae*. The specimens from the very cold area of the Grand Banks are intermediate between *polaris* and *borealis*, but a giant specimen from Western Bank (resembling the type of *L. acervata* forma *aphelonota*) has pedicellariae of *borealis*. (Pl. 30, fig. 2.)

Among the specimens of *L. polaris borealis*, one from Caribou Island and one from Gaspé, Quebec (M. C. Z., Nos.; 1307, 1308, pl. 35, figs. 1,2), are remarkable for having longer and more widely spaced spines. In the Gaspé example (R 150 mm.) the spines are conical, 3 to 4 mm. long, spaced their length or more apart, and along the radial line sometimes aggregated in groups, of which the central is largest. Other specimens have well spaced but shorter and subcapitate spines. It is these latter that resemble *L. katherinae;* while the Gaspé example would correspond to a poorly developed *L. coei.*

To summarize, the following divisions of *L. polaris* are recognizable:

L. polaris polaris, high arctic waters of eastern North America.

L. polaris borealis, a very slightly differentiated southern form of the above.

L. polaris acervata, Arctic Ocean, Bering Sea, and region immediately south of Alaska Peninsula.

L. polaris katherinae, off Washington, probably intergrading with above.

Verrill discarded the name *polaris* since the combination *Asterias polaris* (Müller and Troschel), 1842, was antedated by *Asterias polaris* Sabine, 1824 (for *Ctenodiscus crispatus*). Müller and Troschel, however, described the species as *Asteracanthion polaris*. On account of the structure of its gonads, which open ventrally, *polaris* is more naturally classified in *Leptasterias*. The specific name *polaris* is therefore tenable, so long as it is not combined with *Asterias*.

Specimens of Leptasterias polaris examined

Locality	Depth	Nature of bottom	Number of specimens	Collection
	Fathoms			
Godhavn, Disco Island, Greenland			4	Riksmuseum, Stockholm.
Disco, Greenland	27	Clay	1	Do.
Davis Strait, 63° 47′ N., 52° 26′ W	35	Shells	1	Do.
West Greenland (Omenak)	30–40	Stones	1	Do.
West Greenland (Rittenbenk)	35	Clay	1	Do.
West Greenland (Gothaab)	[1] 100–200		4	Do.
Godhavn, Disco Island, Greenland			5	U.S.N.M., 15815.
Greenland			6	U.S.N.M., 15816; Howgate expedition Doctor Pavy.
Davis Strait	40		1	U.S.N.M., 38834, N. P. Scudder.
Hudson Bay (Cape Churchill)			1	U.S.N.M., 39912, E. A. Preble.
Hudson Bay (Richmond Gulf)	15		1	U.S.N.M., F. Johansen.

[1] 1 specimen.

Specimens of Leptasterias polaris borealis examined

Locality	Depth	Nature of bottom	Number of specimens	Collection
	Fathoms			
Battle Harbor, Labrador	1		1	U.S.N.M., 19627.
Henley Harbor, Labrador			2	U.S.N.M., 8834, W. A. Stearns.
Egg Harbor, Labrador	20	Rocks	1	U.S.N.M., 36964, Owen Bryant.
Bonne Esperance, Esquimaux Bay, Labrador			2	U.S.N.M., 5835, W. A. Stearns.
Labrador			2	U.S.N.M., 15813, 1376.
Caribou Island, Labrador			2	Mus. Comp. Zoöl., 1307; topotypes.
Gaspé, Quebec			1	Mus. Comp. Zoöl., 1308.
Godbout, Quebec			2	U.S.N.M., 31922.
Grand Banks, Newfoundland			1	U.S.N.M., 15814.
Edge of Grand Banks	200		1	U.S.N.M., 24503.
Western Bank			2	U.S.N.M., 14339.
Off Cape Race, Newfoundland	30	Pebbly	1	U.S.N.M., Owen Bryant.
Grand Banks, Newfoundland, 46° 13′ N., 51° 46′ W.	59	Stone and shells	1	Riksmuseum, Stockholm.
Grand Banks, Newfoundland, 47° 20′ N., 52° 29′ W.	91	Small stones, mud	1	Do.
Grand Banks, Newfoundland, 45° 53′ N., 51° 56′ W.	50	Small stones, shells.	4 juv.	Do.
Station 2463, off Newfoundland, 45° 44′ N., 54° 27′ W.	45	Broken shells 30°	1	U.S.N.M., 11177.
Station 2495, off Nova Scotia, 44° 10′ N., 59° 23′ 45″ W.	44	Hard, 32°	1	U.S.N.M., 11430.

LEPTASTERIAS POLARIS ACERVATA (Stimpson)

Plate 30, Figures 3–5; Plate 31; Plate 32, Figures 1, 2; Plate 33, Figure 7; Plate 36, Figures 2, 3; Plates 37–40

Asterias acervata Stimpson, Proc. Boston Soc. Nat. Hist., vol. 8, 1862, p. 271. Bell, Proc. Zool. Soc. London, 1881, p. 494.—Murdoch, Rep. Int. Polar Exp. Point Barrow, 1885, p. 158.—Ludwig, Zool. Jahrb. 1886, p. 287.—Sladen, Challenger Asteroidea, 1889, p. 818.—Verrill, Shallow-water Starfishes, 1914, p. 107, pl. 27, figs. 1, 2 (not pl. 106, fig. 3=*dispar*.).

A. polaris var. *acervata* Verrill, Amer. Nat., vol. 43, 1909, p. 545.

Asterias polythela Verrill, Amer. Journ. Sci., vol. 28, 1909, p. 68; 1914, p. 104, pl. 55, figs. 1, 2; pl. 70, fig. 8; pl. 72, fig. 2; pl. 84, figs 3, 4; pl. 79, figs. 1–2*a*.—A. H. Clark. Rep. Canadian Arctic Exp., 1913–1918, 1920, p. 8*c* (Port Clarence).

Asterias philippii Bell, Proc. Zool. Soc., 1881, p. 511, pl. 47, figs. 1, 1*a*. See Fisher, Ann. and Mag. Nat. Hist. Ser. 9, vol. 18, 1926, p. 198.

Stenasterias macropora, A. H. Clark, Rep. Canadian Arctic Exp. 1920, p. 9*c* (Port Clarence).

Asterias acervata borealis, A. H. Clark, Rep. Canadian Arctic Exp., 1920, p. 8*c* (E. of Cape Lisburne).

Leptasterias polaris acervata Fisher, Ann. and Mag. Nat. Hist., ser. 9, vol. 12, 1923, p. 599.

This name is intended to designate the polymorphic representative of *L. polaris* which inhabits Bering Sea and adjacent parts of the Arctic Ocean and north Pacific. A "composite diagnosis" covering all of its phases is of no practical value since the race does not exist as a composite but in the guise of three major formae which intergrade. These formae are: *aphelonota* Fisher, *acervata* Stimpson, and *polythela* Verrill.

The race as a whole differs from *L. polaris polaris* of West Greenland waters in this accentuated polymorphism (one phase of which, *polythela*, is not represented east of Alaska) and in the larger size of the straight pedicellariae.

In the order of their degree of differentiation from typical *polaris*, the formae stand as follows:

1. Abactinal spines small, close-set, of nearly uniform size, without regularity of arrangement and without any trace of aggregation into convex groups—*aphelonota*.
2. Abactinal surface with a variable number of convex groups of spines (often in three ill-defined longiseries), the subcentral spine of the group usually larger than the others—*acervata*.
3. Abactinal surface with large, conical or acorn-shaped spines, typically solitary, in twos or occasionally larger groups, arising abruptly from an irregularly reticulate spinulation of small, capitate, unequal spinelets—*polythela*.

The type of *Leptasterias polaris acervata* is No. 1336, U. S. National Museum, Bering Strait, clean gravelly bottoms, 5 to 15 fathoms. (Further details under forma *acervata*.)

Forma APHELONOTA, new forma

Plate 31, Figures 2, 2*a*–2*c*, 3, 3*a*, 3*b*, 4; Plate 32, Figure 1, 1*a*–1*h*; Plate 33, Figures 7, 7*a*–7*c*; Plate 36, Figures 2, 3

This forma is based upon a giant specimen from station 2850, off the Shumagin Islands, 21 fathoms, which has the following characters: R 245 mm., r 41 mm., r = 6 r; breadth of ray at base 43 mm. Rays long, rather slender evenly tapered to the pointed extremity; rays constricted at base; disk rather small; interbrachial sulcus hidden by contiguous sides of adjacent rays; abactinal surface of rays well arched, closely studded with small, bluntly pointed or obtuse spines of pretty uniform length, arranged in loose groups of two or three to eight, corresponding to the size of the underlying plate; papular areas small; abactinal plates very numerous closely and irregularly reticulated; superomarginal spines in vertical combs or groups of three to six, usually four, to a plate; inferomarginal spines two or three to a plate, conspicuously longer and heavier than the superomarginals, which in turn are slightly longer than the dorsolaterals; two series of actinals, similar to inferomarginals; adambulacral plates diplacanthid; dermal straight pedicellariae subconical to broadly wedge-shaped with five teeth similar in general appearance to those of *acervata*.

Description.—The well-arched abactinal surface is closely beset with uniformly small spines of nearly equal length but of unequal thickness, arranged without any order, in loose groups, running into one another, and inclosing relatively very small papular areas. Reference to a cleaned ray shows that these groups correspond to the larger, primary, abactinal plates, which carry five to seven spines, while the smaller intermediate plates carry one to three. The spines are therefore arranged in a close reticulum but this is masked by the very numerous abactinal plates, the smallness of the meshes of the skeleton, their irregularity, and by the fact that the spines are in groups, not in single file. The spines vary considerably in form, but are usually cylindrical at the base with a slightly swollen, tapered, coarsely sulcated, bluntly pointed or round tipped end. Others, especially on the disk and sides of the ray are rather more elongate and more pointed than the majority from the median radial area of the ray; and on the outer third of the radial area the spines are blunter than they are proximally. Here and there a spine is perhaps a third longer and considerably thicker than the average which are 2 to 2.5 mm. long and 1 mm. thick.

The smaller spines are about 1.5 mm. long by 0.5 or 0.6 mm. thick varying with their position on disk and ray.

Superomarginal plates rather low on the side of ray. Superomarginal spines a little longer than the dorsolaterals and intermediate between these and the inferomarginals which are decidedly stouter and longer. The superomarginals form a vertical comb, or sometimes a group of three to five (occasionally six) to a plate the median generally the largest. Their general form is clavate with a tapered, blunt, sometimes compressed end, and the distal spines are faintly sulcated. The proximal spines are sometimes "eroded" having a flattened area on the upper (and under) side, converging, in some cases, into a sort of shallow groove on the distal part of the spine. There is no well defined supramarginal channel although the series of papular areas is here more regular on account of the regular series of superomarginal plates. Intermarginal channel practically non-existent owing to the relatively small size of the intermarginal papular areas and the heavy wreaths of pedicellariae which pretty well fill up the channel.

Inferomarginal spines conspicuously longer and stouter than the superomarginals, two or three to a plate, clavate, more or less compressed, blunt to subtruncate and frequently with definite eroded or sunken areas on the upper side of the spine. The spines stand in an oblique series of two or a group of three.

There are two series of actinal plates with a rudimentary third series at the base of some of the rays. The spines, one or two to a plate, are very similar to the inferomarginals, even a little heavier near the base of ray and some are quite definitely subspatulate and truncate. The outer side is slightly concave as in the case of the inferomarginals, this taking the form of a groove or of a sunken area. The whole actinal surface has a very bristling appearance, and one may count from the upper edge of the superomarginals to the adambulacral spines eight or nine spines, or in exceptional instances one or two more.

Adambulacral plates diplacanthid, and as is usual in such cases the slender furrow spine of alternate plates stands further into the furrow than the stouter inner spine of the intervening plate. In effect, the armature of alternate plates is set a little more toward the outer edge of the plate. The spines are mostly terete, slender, round-tipped, slightly tapered, or untapered, and many of them have a slightly sunken area on the outer side near the tip, as in the case of the actinals. There are four pairs of contiguous plates making up the adoral carina. On a few proximal plates there are three spines. The spines lengthen toward the mouth plates, the longest on the adoral carina (one to a plate) being about as long as the first five adambulacral plates (6.5 mm.).

The actinostome is very small. The oral armature consists of two heavy spatulate, round-tipped or subtruncate apical spines to each plate, and a cylindrical suboral spine similar to the adambulacral spines. The larger, more median, of the two apicals is nearly twice as long (4 mm.) as as the short plate, and its breadth varies on the different plates.

Papular areas smaller than the primary plates and with the distribution common to the genus. The papulae are abundant and fill the spaces between the groups of spines.

Straight pedicellariae. (Pl. 31, fig. 4; pl. 32, figs. 1, 1*a*–1*h*.) Conspicuous subconical, heavy, round-tipped pedicellariae with three or four, occasionally five, terminal teeth are abundant abactinally, especially toward the sides of the area, on the marginal and actinal plates, and also sometimes on the bases of the spines. Some have broad, heavy jaws with three or four teeth and the back of the jaw sometimes grooved, while in others the jaw rapidly tapers and the end is pointed with only two or three teeth, or even without teeth. The heavier kind might be described as broadly wedge-shaped. The largest measure 1.15 mm. long by 0.8 mm. broad at base (side view), but many lateral and abactinal ones are only 0.7 mm. long. Smaller, broadly lanceolate, compressed pedicellariae of various sizes down to that of the crossed sort, occur on the adambulacral spines (especially those bordering furrow) and oral spines; and others, also small and lanceolate, or lanceolate-ovate, occur on the actinal and furrow face of the adambulacral plates.

Crossed pedicellariae (pl. 31, figs. 2, 2*a*–2*c*, 3, 3*a*–3*b*) are very abundant, forming heavy wreaths around all the abactinal and superomarginal spines, and three-quarter or half wreaths around the inferomarginal and actinal spines, filling up practically all the space between the spines. The adambulacral spines are provided with large clusters, and the pedicellariae are of different form from the abactinal, the jaw having a longer cutting edge. These are a little narrower than the corresponding pedicellariae of *acervata* and *polythela*. As compared with typical *polaris*, northern *acervata*, and *polythela*, the side view of the abactinal pedicellariae shows the lip extending less far down on the side of the jaw. Abactinal pedicellariae measure about 0.27 mm. long, while the adambulacral are about 0.33 to 0.45 mm. long, the larger being less numerous.

The madreporic body is circular, slightly convex, and situated about mid r.

Anatomical notes.—The abactinal plates are very numerous, irregularly lobed, and form a very close, irregular reticulum, the irregular spaces of which are usually smaller than the primary plates. The supramarginal spaces are a little larger than the plates. About 15 to 18 of the spaces can be counted across the base of the ray between the two superomarginal series of plates, and about the same number of larger plates, although the plates are so unequal in size and irregular in distribution that there is no accurate method of computation. The superomarginals are a little larger than the largest abactinals, are four lobed, and imbricate strongly, all being spiniferous. The inferomarginals and actinals are smaller, decreasing in size toward the furrow and are strongly united by their internally carinate dorsoventral lobes. The ambulacral ossicles are moderately compressed, there being 10 in the space of 10 mm. (at the base of the ray).

The ovaries of the type are rather large spindle-shaped organs subdivided into many lobules. They taper to a point and are therefore similar in form to those of *L. acervata* and unlike the somewhat globular or sausage-shaped ovaries of *L. camtschatica* and allies. The ovary is attached rather low on the septum and the duct turns downward, as in other members of the genus, to open ventrally, although the apertures are not visible on this particular specimen.

Variations.—This forma is divisible into at least two groups which may have a different origin. The typical form has very numerous, close-set abactinal spines, several superomarginal spines to each plate, and large bivalved straight pedicellariae.

The bristling armature of the sides of ray, due to the vertical combs of marginal spines is noticeable. (Stations 2850, 3214.) The less acervate examples of forma *acervata* are near this subforma.

The other subforma has less closely placed abactinal spines, there are only one or two superomarginal spines to a plate, and the straight pedicellariae are less heavy. This variation resembles *polythela* with suppressed major spines. A specimen from Kodiak has one or two spinelets of the carinal series enlarged. Old Harbor, Kodiak; Port Clarence.

Type.—Cat. No. E 1491, U.S.N.M.

Specimens examined.—Type, station 2850, vicinity of Shumagin Islands, Alaska (54° 52′ N., 159° 46′ W.), 21 fathoms, broken shells, bottom temperature 48.2° F., one specimen. (Pl. 25, figs. 2, 3.)

Station 3214, South of Alaska Peninsula (54° 13′ N., 163° 06′ W.), 38 fathoms, gray sand, gravel, one specimen.

Old Harbor, Kodiak Island, August 11, 1888 (*Albatross*), one specimen.

Port Clarence Bay, Alaska, 2 to 3 fathoms, Canadian arctic expedition.

Forma ACERVATA (Stimpson)

Plate 30, Figures 3, 3*a*–3*f*, 4, 4*a*; Plate 32, Figure 2, 2*a*–2*c*; Plate 37; Plate 38, Figure 1

Asterias acervata Stimpson, 1862, p. 271.

This is the forma to which the type specimen of *Asterias acervata* belongs (No. 1366, U.S.N.M.). The type, however, is an extreme rather than a mean of the forma, being on the border toward *polythela*. Forma *acervata* represents a rather heterogeneous series of subformae connecting *aphelonota* with *polythela* and its type is intermediate between average *acervata* (pl. 37, fig. 4) and typical *polythela*. The forma may be characterized as follows:

A large 6-rayed *Leptasterias* extremely variable in detail, but characterized by having certain of the abactinal plates (often in three irregular series) larger than the rest and armed with convex groups of coarse, capitate spines of which the central spine is usually the largest; the ends of the spines subglobose to subconical, rather finely striated; other abactinal spines well spaced, smaller, but similarly formed; superomarginal spines one, two or even three to a plate, longer and slenderer, clavate at times; inferomarginals similar, but heavier, one or two to a plate; one or two series of actinal spines (one to a plate), similar to inferomarginals; adambulacral spines frequently alternating one and two; furrow spine of alternate plates slenderer, tapering, more advanced into furrow; consecutive plates with sometimes only one spine or sometimes two; straight pedicellariae medium to large size, very broadly lanceolate in profile, R = upward of 6 r. Largest specimen, R 154 mm., station 3496.

Description.—Forma *acervata* is difficult to describe in other than rather general terms because it is so unstable. The abactinal surface is especially inconstant to stereotyped detail, although maintaining a recognizable facies. The spinulation of the marginal plates is scarcely more uniform. All specimens which show a tendency to have convex groups of slightly to conspicuously enlarged but subequal spines are included herein, the extremes being well shown on Plate 37, Figures 1 to 4; Plate 38, Figures 1, 2. As mentioned above the actual type is intermediate between typical or average *acervata* and those specimens of *polythela* with several prominent spiky spines in a group, or a single spine surrounded by enlarged secondary spines, as shown on Plate 38, Figures 2, 3. A specimen with R 82 mm., r 18 mm. (R = 4.5 r) has the following features:

Abactinal spines, as the plates, are of two very diverse sizes. There are about three longitudinal series, quite irregular, but in other specimens sometimes fairly regular, of spaced heaps of capitate spines with swollen oblate hemispherical, subglobose, ovate (or in other specimens even acorn-shaped) vertically striated tips. The central spine is much the largest of any of the group, while the subsidiary members, unequal in size, form a circle or irregular group around it. The diameter of the largest spines is about 1.5 mm. and that of the smaller 0.4 to 0.75 mm. Scattered closely over the abactinal surface in irregular lines, rather vaguely defining a reticulum, are numerous usually unequal small spinelets (0.4 to 0.6 mm. diameter) which duplicate in miniature the form and sculpturing of the acervate spines. Just above the superomarginals is a zone variable in width, rather free from spinelets and filled with numerous lanceolate, blunt, straight pedicellariae about 0.5 mm. long. These are sometimes incipiently toothed. Smaller ones are scattered over the dorsal surface. The spines are surrounded by small crossed pedicellariae in one or two circles, the interstices between the spines of the groups being filled with them. In alcoholic specimens the pedicellariae seem to arise from cushions of tissue surrounding the spines and spinelets, and have the appearance of being everywhere numerous. In large specimens there may be three tiers around the spines.

Superomarginal spines very variable in length and caliber, but slenderer and sometimes larger than the major dorsal spines. In the type subforma each plate has one spine except the distals which sometines have two. The spines are blunt, cylindrical-clavate, faintly striated longitudinally and the tips are often compressed. Other variations have two and even three spines (in such cases smaller than when one is present) on the proximal plates and three and four on the distal (for example another larger specimen from station 3247, one from stations 3235, 3290, 3274, etc.; see variations). In such specimens the abactinal acervate spines form usually more rounded heaps, without a very prominent central member, but this is not invariable (as stations 3233, 3274).

The type subforma has a row of inferomarginal spines similar to but longer and heavier than the superomarginals, and a series of actinals similar to but a little smaller than the inferomarginals. Other varieties have two equal or unequal inferomarginals, and two series of actinals, the same specimens having also two or even three superomarginals proximally. (See variations.) The superomarginal spines have a dense wreath of about three tiers of crossed pedicellariae, while the inferomarginal and actinal spines have thick clusters on the outer face. In the type subforma the intermarginal channel, owing to the single row of superomarginal and inferomarginal spines, is conspicuous (but it is practically obliterated in varieties with multiple rows of marginal spines) and is armed with lanceolate blunt pedicellariae.

As might be expected, when there is little stability in the number of marginal spines, the adambulacrals are variable. In the type subforma the spines most commonly alternate two and one, the furrow spine of alternate plates being more advanced on the furrow face of the plate, as in typical *Asterias* (although not so far).

This furrow spine is slenderer than the subambulacrals, tapering, bluntly pointed or obtuse, while the other spines are heavier, subcylindrical, round-tipped, sometimes a trifle clavate or compressed. A considerable number of consecutive plates may have but one spine, or may have two. The spines bear thick, subterminal clusters of broadly lanceolate, unequal, straight pedicellariae, together with smaller blunt crossed pedicellariae, the latter being more numerous on the subambulacral than on the furrow spines, where the straight pedicellariae predominate and are of larger size. Some of the specimens with numerous marginal spines have two and three adambulacral spines on a portion of the proximal part of the ray. The third (and outer) spine is shorter than the others. The armature of the furrow margin appears crowded by reason of the more numerous spines and their heavy masses of pedicellariae; station 3274.

Four pairs of adambulacral plates are contingent behind the mouth plates (fewer in the small specimens). The mouth plates are small, not especially sunken, scarcely wider than the first pair of combined adoral adambulacral plates, and their greatest length equals that of the first two or two and a half adambulacrals. There is a very short, stumpy, pedicellaria-clad spine directed across the mouth of furrow (and reaching about to the middle); another longer spine, tapering and blunt, directed over actinostome, and a third, suboral, still longer, slightly tapering, and standing erect like the following adambulacral spines.

The madreporic body is prominent, convex, situated at about the middle of r, and has irregular radiating striae.

Papulae numerous in small irregular groups dorsally and irregularly distributed as the meshes of the skeleton; prominent just above, between, and just below marginal plates, and present also between the actinal plates (when there is more than one series), and adjacent to adambulacrals.

Straight pedicellariae (pl. 32, figs. 2 to 2*e*) are usually abundant on all surfaces and on the adambulacral spines and vary considerably in size, the largest usually occurring in the axillary channels. (See variations.) The larger straight pedicellariae of *acervata* is a distinguishing feature from *polaris*. Arctic specimens have proportionately more numerous straight and fewer crossed pedicellariae on the adambulacral spines than have southern examples.

Crossed pedicellariae (pl. 30, figs. 3, 4) vary greatly in size in different parts of the range. The abactinal measure from 0.22 to 0.3 mm. in length. The arctic specimens have pedicellariae more closely resembling those of *polaris* than have the southern Bering Sea forms. For measurements see explanation of plates. Numerous crossed pedicellariae occur between the abactinal spines as well as immediately surrounding them.

Color in life: Above, clouded with very dark brown; madreporic plate cream-colored. Sides of rays and actinal surface, yellowish cream color (Stimpson).

Anatomical notes.—The cleaned skeleton of the ray consists of a rather close irregular network of very unequal, irregular plates, there being a variable number of large convex, irregularly lobed plates corresponding to the groups of spines. These seem to have no order of occurrence except that the majority are near or on the radial line. The intermediate and smaller primary plates are oblong, and of various polyhedral forms with rounded corners. Twelve to fourteen plates can be counted across ray between the superomarginals. The latter as well as the inferomarginals, and actinals are arcuate, broad lozenge-shape or incipiently four-lobed, and imbricate to form transverse as well as longitudinal series, lower and adoral ends outermost.

The interbrachial septa are stout and strongly calcified, and their interradial dimension is about one-half r. The actinostomial ring is stout, decidedly narrow, so that the actinostome is small, and the odontophore is not conspicuous as in *Asterias amurensis.* The ambulacral furrow is rather narrow and the ambulacral plates are not crowded.

The intestinal coecum is of the irregular tubular form with a common saccular portion adjacent to the intestine. The hepatic coeca are very large and extend to the end of the ray. The eversible stomach has large radial diverticula, the central portion being defined by the inner edges of the interbrachial septa. The septa as mentioned above are about one-half r in breadth. The sides of the ray are divided into a series of lateral pockets by means of dorsoventral partitions similar to those of *Asterias amurensis.* Into these the lateral diverticula of the hepatic coeca extend. The gonads are attached to the interbrachial septa about midway between the dorsal and ventral surface and about one-fourth of r inward from the apex of the interbrachial angle. The gonoduct passes outward and downward in the septum, and opens on the ventral surface about one-fourth r from the interbrachial angle, between the two rows of marginal plates, at the end of a low papilla often guarded by a major pedicellaria. The papillae are very close to the interradial line, one on either side for each interbrachium, and are difficult to find. The gonad is in form spindle-shaped, a little over one-fourth to one-half R in length and consists of numerous short lobulated branches surrounding a central duct. The eggs are large.

Variations.—As an example of the variations which may occur at one locality, 10 specimens from station 3233, 7.25 fathoms, Bristol Bay, are very informing. R varies from 31 to 93 mm., seven examples being large. The range of difference in abactinal armature is shown by Plate 37, Figure 1, Plate 38, Figures 1 and 2. The first two are from station 3233; the last is from the Arctic Ocean, but a specimen from station 3233 is practically the same. Of the 10 specimens: (*a*) One is Plate 37, Figure 1; (*b*) two are between this and Plate 38, Figure 1; (*c*) five fall in a class with the latter or have slightly more prominent heaps of spines. For instance, in three of the five, the central spine is more accentuated. (*d*) One is like Plate 38, Figure 2. The variation in superomarginal spines is as follows: (*a*) Usually three; (*b*) young, one or two; (*c*) four specimens have generally two spines; two specimens (one of which is young) have one spine or sometimes two on distal plates; (*d*) one spine (typical of *polythela*). Of inferomarginal spines *a* has usually two, the others one.

Specimens from stations 3231 and 3232 exhibit the same class of variations, ranging through the same amount of difference with the exception that there is no example so near *polythela* as that in class *d* above.

Specimens from stations 3496, 3525, 3557, and No. 39984, off St. George Island, have very large bivalved straight pedicellariae like those of the typical *aphelonota.* All are from the region of the Pribilof Islands. Inasmuch as some of the specimens of *polythela* from the same locality show a similar variation it would be interesting to know the cause.

Of the above, two large specimens, No. 39984 and station 3496 are unlike the usual run of *acervata*. They have much fewer, more widely spaced, larger spines. No. 39984 abactinally resembles *L. katherinae*, but has the crossed pedicellariae of *acervata;* station 3496 has a few larger spines here and there and one series of superomarginals. It may perhaps be a variant of *polythela*. Both have larger and more widely spaced spines than f. *aphelonota*.

Young.—The smallest specimen has R 8.5 mm. (station 3233) and could not be accurately identified if it were not accompanied by adults. The rays are moderately stout, depressed, and the abactinal spines unequal, comparatively coarse, and relatively few. Even at this early age a few spines here and there in the radial region overtop the others and are usually distinguishable by having one to three crossed pedicellariae on their bases. There is one superomarginal spine to a plate and one inferomarginal, a little longer, each with several minor pedicellariae. Adambulacral spines either one or two, rather irregularly; a few straight pedicellariae scattered along the furrow face. One pair of adambulacral plates meet behind the mouth plates. First two or three tube-feet biserial, then quadriserial in quincunx. Papulae solitary, none actinal, but an intermarginal series present.

Another example with R 10.5 mm. is essentially the same.

Small examples with R about 30 mm. show most of the varietal differences of the adult, but in a less accentuated form, since the spines are fewer. There are usually one inferomarginal, one actinal, and either one or two superomarginal series of spines. Sometimes a second inferomarginal spine of smaller size. Crossed pedicellariae are plentiful. These and the absence of large bivalved denticulate intermarginal and supramarginal straight pedicellariae will serve to distinguish young *acervata* from the closely similar shore form, *Leptasterias alaskensis*, found along the Aleutian Chain from Unalaska to Attu and Agattu.

The specimen figured by Verrill (1914, pl. 106, fig. 3), Nazan Bay, Atka, as young *acervata* is referable to *Leptasterias camtschatica dispar*.

Type.—Cat. No. 1366, U.S.N.M., William Stimpson. The specimen figured by Verrill (1914, pl. 27, figs. 1, 2) is not the type, as stated, but is Cat. No. 1367, U.S.N.M., Arctic Ocean, Captain Rogers. It is, however, practically identical with the type.

Type locality.—Bering Strait, clean gravelly bottom, 5 to 15 fathoms (Stimpson).

Distribution.—Forma *acervata* is found from the Arctic Ocean to Bristol Bay, Bering Sea, Attu Island, and on the Siberian coast to Indian Point. Its known temperature range is slightly higher than that of *polythela*, but the temperatures of arctic stations are not known.

Specimens examined.—Eighty-nine.

Specimens of Leptasterias polaris acervata forma acervata examined

Station	Locality	Depth	Nature of bottom	Bottom temperature	Number of specimens	Remarks
		Fathoms		° *F.*		
3231	Bristol Bay, Bering Sea	12	Stones		19	U.S.N.M.
3232	do	10. 5	Pebbles, stones		20	Do.
3233	do	7. 25	Sand, pebbles	44. 5	10	Do.
3234	do	5	Gray sand		1	Do.
3235	do	11	Black sand		1	Do.
3247	Mouth of Bristol Bay	17	Pebbles, stones	40. 6	2	Do.
3274	North end Alaska Peninsula	19	Black sand, shells		2	U.S.N.M. (intermediate).
3277	do	18	Gravel, sand, rocks	43. 2	1	U.S.N.M.
3279	Mouth of Bristol Bay, near Alaska Peninsula.	16	Black sand		1	Do.
3290	do	16	Gray sand		3	Do.
3300	Bristol Bay	15	Pebbles	42. 2	2	U.S.N.M. (intermediate).
3496	Southwest of Pribilof Islands	41	Gray sand, stones, green mud.	39. 9	1	U.S.N.M.
3525	West of Pribilof Islands	29	Black sand, shells	41. 6	1	Do.
3557	do	26	Sand		3	Do.
3559	do	39	Gray sand, broken shells	42	1	U.S.N.M. (intermediate).
4795	Off Avatcha Bay, Kamchatka, 52° 46′ 50″ N., 158° 44′ 30″ E.	69–48	Green sand, pebbles		2	Albatross, 1906.
	Bering Strait	5–15	Gravel		1	Wm. Stimpson, 1366, type.
	Arctic Ocean				2	Captain Rogers, 1365; 1367.
	Cape Lisburne, Alaska	5–7	Sand, gravel		2	W. H. Dall, 1880; 6111.
	do				1	15714, beach after gale.
	Plover Bay, Siberia	15–26	Rocky		4	6112, W. H. Dall.
	Off Indian Point, Siberia	17	Gravel		2	6086, W. H. Dall.
	Head of Norton Sound, Bering Sea	5			1	7622, John Murdoch.
	St. Michaels, Alaska	1			1	15842, L. M. Turner.
	Chickagoff Harbor, Attu Island	5–7			3	
	Off St. George Island, Pribilof Islands	40				39984, G. D. Hanna.
1006	North coast Siberia, 67° 7′ N., 173° 24′ E.	15	Clay, stones		1	Riksmuseum, Stockholm, Vega Expedition.
1072	Off Bering Island	65–75			1	Do.

Forma POLYTHELA (Verrill)

Plate 30, Figure 5, 5*a*, Plate 31, Figure 1, 1*a*–1*f*; Plate 38, Figure 3; Plates 39, 40

Asterias polythela VERRILL, 1909, p. 68.

This forma comports itself more like a conventional species than does *acervata*. When approximately typical (pl. 39, and 40) it is very easily recognized by reason of the few large rather widely separated upright abactinal spines. It is connected with forma *acervata* by numerous intermediate forms of which the type of *acervata* is one.

Diagnosis.—A large to medium-sized, 6-rayed form, with rather slender to moderately stout, depressed to well arched rays and small disk; abactinal surface of rays with 5 to 30 large, conical or acorn-shaped spines, typically solitary, or in twos, or occasionally more, borne on convex plates much larger than the others, and arising from an irregularly recticulate spinulation of small capitate, unequal spinelets; typically one or two superomarginal spines proximally, three to five short tubercles distally; usually one inferomarginal, and one or two series of actinal spines; adambulacral spines proximally two, distally one and two alternating; crossed pedicellariae abundant; marginal and actinal straight pedicellariae frequently with broadened toothed jaws. Differing from *acervata* in having larger conical dorsal spines with no, or only a very few, smaller accessory tubercles. R = upward of 6.25 r, and upward of 200 mm.

Description.—The type form as described and figured by Verrill, and abundantly represented in the collection at my disposal is about the most easily recognized asteriid of Bering Sea and the adjacent parts of the Arctic Ocean. It exists in nature, however, in various guises which depart from the characteristic form above alluded to, and bridge pretty completely the gap separating the type subforma from that of *acervata*.

The largest specimens, upward of 200 mm. major radius, are considerably bigger than any *acervata* that I have examined.

R 200 mm., r 32 mm., R = 6.25 r; breadth of the ray at widest part 40 mm., at base 33 mm. Rays swollen at base, very gradually tapered to a blunt extremity; rays and disk usually well arched and sometimes inflated.

Abactinal surface beset with numerous, unequal, spaced capitate spinelets, constricted above the base, then enlarged into a subglobose, acorn-shaped, or swollen, subtruncate extremity, usually with weak longitudinal striations. These spinelets are similar to those of *acervata*, and define rather irregular small sunken areas occupied by papulae and pedicellariae. Arising from the general level are relatively few much larger convex plates, bearing stout striated subconical or acorn-shaped blunt or subacute tubercles, which in large specimens attain a length of 3 mm., or 5 mm., including the convexity of the plate. These tubercles vary in number and position but are more frequent along the radial line than on the dorsolateral regions. Occasionally they form three irregular series, but with more spines in the radial than in either lateral row. They stand singly or in groups of two to five (in which case one is usually larger than the others); and in some specimens certain of the minor spines may form intermediate tubercles by enlargement. The disk may entirely lack the large spines (type variety) or may carry upward of 20; station 3251. The number of large spines on the rays varies greatly, ranging in general from 5 to 30 to each ray. A very large example from station 3440 (pl. 40, fig. 2) has relatively few, mostly on the outer half of the ray, while a medium-sized specimen from station 3251 (R. 78 mm.) has about the maximum number in three series. As soon as the large primary spines are accompanied by smaller ones so as to form an acervate grouping, the dorsal surface approaches in appearance exaggerated cases of the type variety of *acervata*. (Pl. 38, fig. 2.) In definitely intermediate examples which can not be assigned to either *polythela* or *acervata* the enlarged spines occur in groups as in *acervata*, but the central spine greatly overtops the others and is conical in form. The superomarginal spines may or may not stand singly on a plate.

Crossed pedicellariae are very numerous on the abactinal surface, densely covering the slopes of the plates leading up to the base of the large spines and surrounding the minor spines in from one to three circles. Much less numerous straight pedicellariae are scattered over the abactinal surface usually on the edge of papular groups. They rather increase in number and size toward the marginal spines, reaching a length of from 1 to 1.25 mm. in the biggest specimens, and 1 mm. in an example with R. 170 mm. The form is broadly lanceolate to broadly oval, or even subelliptical, more or less compressed, and the end of the jaws are either smooth (station 3251) or are provided with one to five short, interlocking teeth (also station 3251), both being very large specimens. In a slender rayed variety from station 3530 and station 3518 the straight pedicellariae are fewer than normal.

What might be called the typical arrangement of marginal and actinal spines, if there were not so many exceptions, is one series for each of the marginal rows, and a single series of actinal spines—three in all; or two series of actinal spines (proximally at least) in the largest examples—four in all. In three very large specimens from station 3251 two have a single superomarginal spine (except sporadically two) on the proximal two-thirds or three-fourths of ray, then a transverse series of two or three short tubercular spines; the third has mostly two spines except at the very base of the ray where there is one, and on the outer fourth or fifth where there is a transverse series of four or five short tubercles; of the first two, one has frequently two inferomarginal spines and but one actinal series, the second has one inferomarginal spine to a plate and two series of actinal spines and plates of nearly equal size; the third has occasionally two inferomarginal spines, and two series of actinals, the inner much the smaller. A second superomarginal spine, smaller than the primary is not uncommon, and even a third may be present in an otherwise typical specimen; station 3441. The distal plates very often have three to five tubercles, but may have only one. Irregularity in the number of inferomarginal spines is less common but occurs. The superomarginal spines are decidedly smaller than the dorsals, subconical, sometimes compressed, with pointed, blunt, or irregular tips, and frequently are acorn-shaped distally. The inferomarginals (and actinals also) are abruptly larger if the superomarginals are small, or subequal if they are large, of much the same shape, more or less clavate and slightly bent, the tips being blunt. The superomarginal spines are provided with thick wreaths, and the inferomarginals and actinals with half-wreaths of crossed pedicellariae, with much larger broadly lanceolate to triangular-ovate straight pedicellariae scattered among them. The intermarginal and actinal channels are proximally (and also usually distally) armed with stout, straight pedicellariae of the general form of the dorsals but larger as a rule, with typically broadened jaws ending in several small curved teeth. Some of the pedicellariae (as station 3520) have the jaws nearly as broad as high, viewed from the back, with parallel sides and gently curved margin armed with about five or six teeth. They resemble somewhat the bivalved pedicellariae of Goniasteridae.

The adambulacral spines stand two on a plate on the proximal half or two-thirds of ray, then they alternate one and two. The spines resemble those of *acervata.* Alternate furrow spines are more advanced into the furrow, and are slenderer than the subambulacrals which in turn are much slenderer than the actinals. The furrow spines taper slightly, while the others are usually untapered, subcylindrical (or even clavate), sometimes a trifle flattened. All have large subterminal groups of tapered, unequal straight pedicellariae. The straight pedicellariae are toothless and have narrow jaws viewed from the back; rather acute-ovate from the side. In large specimens there are four pairs of contiguous adambulacral plates behind the mouth plates, the width of this adoral ridge varying somewhat. The first two to four plates have one spine each.

The mouth plates resemble those of *acervata* and each has three spines in similar fashion.

The papulae are numerous in small not very crowded groups of 10, 15, or even more, dorsally, intermarginally, between the inferomarginals and first actinals, and between the first and second where present. The papulae alternate with the spines of the second actinal row, or when this is not present stand, at least in large, specimens, between the first actinals and the adambulacral plates. There is often only one, at most only a few, papulae to each group actinally.

Madreporic body prominent large, slightly convex, with radiating striae. It is situated about at the middle of r.

Straight pedicellariae are similar to those of *acervata* and vary in size but are consistently large; only a very few specimens have them of inferior size. They are generally very numerous, and have either smooth or notched edges.

Crossed pedicellariae (pl. 31, figs. 1–1*b*; pl. 30, fig. 5) are very numerous and vary in full sized specimens from about 0.25 to 0.29 mm. in length, 0.27 mm. being the usual size of the abactinal. The adambulacral spine pedicellariae which have the usual different form are about 0.3 mm. In arctic specimens the general appearance of the pedicellaria is close to that of *polaris*, and as in forma *acervata*, the lip extends farther down on the side of jaw than in southern examples. (Compare figs. 1 and 1*b*, pl. 31.)

Anatomical notes.—The main features of the anatomy are similar to those of *acervata*. The intestinal and hepatic coeca are similar. The latter are relatively very large, especially in the large specimens and reach to the end of the ray. They fill the coelom of the ray and extend into the shallow lateral pockets of the coelom formed by internal partitions. The latter are due to internal dorsal processes of the marginal and actinal plates overlaid by membrane. The gonads of the largest specimens open more in the axils, than on the ventral surface, but this opening is below the superomarginal plates and is distinctly not at all dorsal as in *Asterias*, ss.

An examination of the skeleton reveals no important points of difference. The abactinal plates in large specimens are quite irregular and are crowded in the median region, the meshes being smaller than the skeletal intervals. The supramarginal and intermarginal meshes are the largest. The marginal and actinal plates are regularly four-lobed, the dorsal (internal) lobes being the longest and carinate, so as to support a membranous partition, the series of which, along the side of the ray, act as a support and occasion shallow lateral pockets of the coelom. These elongate dorsal lobes are longest at the base of the ray, and they overlap very broadly the descending lobe of the plate above, the latter being external. In the large specimen from station 3251, there is a third series of small actinal plates which can not be seen from the outside. As mentioned elsewhere the large tubercles are borne on very convex plates much larger than the others. These plates seem to be among the first formed in the young.

Variations.—The principal variations have been stated in the description. It will be necessary only to give a brief summary here.

The number of rays is six, but there is one specimen with five rays from station 3518. The stoutness of the rays varies independently of the size of the specimen, the condition depending partly on the maturity of the gonads, also somewhat upon the amount of deflation at the time of death. Aside from these factors there is an actual individual difference in ray breadth. The breadth of ray at widest part goes into R 4.5 to 6+ times, in the largest examples; and 4 to 5.5 times in the medium-sized specimens; in small examples there is not so much variability. Of course in the above comparisons there is allowance to be made for the increase of ray length with age.

There are no two specimens alike in respect to the distribution, number, and size of the abactinal tubercles, while their form ranges from that of an elongate cone to that of a short acorn, or at the tip of ray to a depressed spheroid, and the tip may be fairly sharp, to rounded. Not only is there variation in number between specimens, but between the rays of the same example. The tubercles are perfectly solitary, surrounded only on the plate by a dense felting of small minor pedicellariae, or there may be 1, 2, 3, 4, or 5 accessory tubercles of various, generally smaller, sizes arising from the same plate. There is scarcely ever more than two *large* subequal tubercles arising from the same plate. Two extremes, that of acervate tubercles and that of mostly solitary spines, are encountered at the same station, 3518, and at this station also is a specimen with the disk bristling with spines (pl. 39, fig. 2) and others without a single spine. About the same extremes are found at station 3251, at which were taken the largest specimens (mostly with few or no enlarged tubercles on disk). (Pl. 39, fig. 1.)

A curious variation is found in a specimen from the Arctic Ocean, north of Bering Straits (steamer *Corwin*, No. 15819); R 96 mm., r 19 mm. The dorsal surface is typical, but the actinal spines are lacking opposite the first 8 to 12 inferomarginals. From this point on there is a single series which extends nearly to the tip of the ray. There is a single series of very short superomarginal spines and proximally a second accessory series of shorter tubercles. The inferomarginals are abruptly much larger and dominate the ambitus. The straight pedicellariae of the dorsolateral and marginal regions are large, with broad, toothed extremities. This is not a variety characteristic of the Arctic Ocean for another specimen collected by the *Corwin*, also No. 15819, Arctic Ocean, north of Bering Strait, has much shorter rays, a conspicuous intermarginal channel, and a relatively broad area between the inferomarginal and adambulacral plates occupied by a series of stout actinal spines.

Specimens not typical and variously diverging toward *acervata* were taken at the following stations, no two of these specimens being closely similar: Station 3236, one intermediate; 3252, one; 3253, one; 3254, two; 3277, three; 3506, one; 3520, two intermediate, the proximal part of the ray of one example being *acervata* and the tip, *polythela;* 4795, one; from this station a typical *polythela*. Arctic Ocean, north of Bering Strait, one. (Pl. 38, fig. 2.)

Young.—From station 3254 along with adults and undoubted young is a tiny specimen having six rays and R 4.5 mm. This is chiefly interesting in having the abactinal surface covered with thin flat subcircular, overlapping plates from some of which arises an erect spinelet; no papulae; two series of tube feet; mouth plates large, like those of the Solasteridae, with two actinostomial spinelets and at the outer end of the plate a larger suboral; one pair of adambulacrals touching behind the mouth plates; one large adambulacral spinelet; actinostome big; a brief series of marginal spinelets in each row. This specimen is of course quite unlike the adult and resembles one of the Asterinidae more than an Asteriidae.

Very small specimens have short, broad, depressed rays. The permanent spines make their appearance early, a specimen with R 9.5 mm. having about 12 in three series on each ray, each surrounded by a circle of relatively large minor pedicellariae. The big plates and spines are among the first to appear and their early differentiation shows that the character is deep-seated. The smaller plates of the adult are secondaries, the prominent plates being the first that are acquired by the young sea star. There are about five series of single dorsal papulae, one intermarginal, and none actinal; no actinal plates; adambulacral spinelets alternating one and two; tube feet in two zigzag series or in four, arranged in quincunx.

The young of *acervata* of the same general size (station 3232, 3233) have much slenderer rays. An example of *acervata* with R 10.5 mm. has several of the radial plates with two or three spines, the character showing itself early in this case, also. The specimen with R 8.5 mm. shows the same tendency.

In specimens of *polythela* with R 15 to 20 mm., the adult characters are readily recognizable, although the actinal plates are wanting and the pedicellariae are still relatively few.

There is no evidence of an *acervata* stage in the development of *polythela*, nor particularly, of the converse.

Type.—Cat. No. 15820, U.S.N.M.

Type locality.—Arctic coast of Alaska, U. S. R. S. *Corwin.*

Distribution.—Bering Sea (Bristol Bay, vicinity of Unimak Island, Pribilofs, St. Matthew Island, Petropavlovsk, Port Clarence) and the Arctic Ocean north of Bering Strait, in from 2 to 59 fathoms, on gray, green, and black mud, or sandy mud, exceptionally on coarse sand or gravel. Temperature range, 31.1° to 44.8° F. This form appears to live on softer bottom and in colder water than does *acervata*. The typical phase of the forma is found on mud or very fine sand, in water under 38°. It is possible that the higher readings of 43° and 44° may be erroneous.

Specimens examined.—One hundred and thirty.

Specimens of Leptasterias polaris acervata forma polythela examined

Station	Locality	Depth	Nature of bottom	Bottom temperatures	Number of specimens	Collection
		Fathoms		° *F.*		
3236	Bristol Bay, Bering Sea	14.75	Gravel, sand, shells	39	1	U.S.N.M.
3244	Mouth of Bristol Bay	4.5	Fine gray sand		1	Do.
3245	do	11.5	Sand, pebbles		3	Do.
3251	North coast Unimak Island	25.5	Fine gray sand	37.5	8	U. S. N. M. (very large).
3252	do	29.5	Black mud	44.8	14	U.S.N.M.
3253	do	36	Mud, sand	35	3	Do.
3254	do	46	Green mud, sand	36.2	13	Do.
3255	do	43	do	37	19	Do.
3256	do	49	Green mud, black shells	35	2	Do.
3277	North of end of Alaskan Peninsula	18	Sand, rocks	43.2	3	Do.
3439	West of Pribilof Islands, 57° 06′ N., 170° 35′ W.	41	Fine gray sand, shells	44	1	Do.
3440	West of Pribilof Islands, 57° 05′ N., 170° 41′ W.	48	Black mud, shells		1	Do.
3441	West of Pribilof Islands, 57° 04′ 20″ N., 170° 52′ 30″ W.	51	do	39	3	Do.

Specimens of Leptasterias polaris acervata forma polythela examined—Continued

Station	Locality	Depth	Nature of bottom	Bottom temperatures	Number of specimens	Collection
		Fathoms		*° F.*		
3506	Northeast of Pribilof Islands, 57° 33′ N., 165° 55′ W.	44	Fine gray sand	38.1	3	U. S. N. M.
3512	North of Pribilof Islands, 57° 49′ 30″ N., 169° 27′ W.	38	Fine, sand, green mud	36.6	1	
3518	Bering Sea, southeast of St. Matthew Island.	36	Green mud	33.9	8	Do.
3519	do	37	Black mud, fine sand	31.1	6	Do.
3520	do	38	Green mud, fine sand	32.2	2	Do.
3522	Northeast of Pribilof Islands, 57° 58′ N., 170° 09′ W.	41	Coarse gray sand, gravel	35.7	10	Do.
3529	Bering Sea, 58° 36′ N., 172° 24′ W	56	Green mud	36.1	1	Do.
3530	Bering Sea, 59° 39′ N., 173° 53′ W	59	Dark green mud, fine sand	34.9	11	Do.
3531	Bering Sea, 59° 55′ N., 174° 17′ W	59	Green mud	35.1	9	Do.
3611	Bering Sea, east of Pribilof Islands	50	Green mud, sand	34.6	1	Do.
4794	Off Avatcha Bay, Kamchatka	58–59	Sand, pebbles		1	Albatross, 1906.
4795	do	69–48	Green sand, pebbles		5	Albatross, 1906 (with *acervata*).
4796	Off Avatcha Bay, Kamchatka	48	Sand, pebbles, shells		4	Albatross, 1906.
	62° 15′ N., 167° 48′ W	20.5			1	Lieut. Geo. M. Stoney, 15835.
	Arctic Ocean, north of Bering Strait				6	U. S. R. S. Corwin, 15818, 15819.
	Arctic coast of Alaska				1	U. S. R. S. Corwin, 15820.
	65° 55′ 15″ N., 168° 09′ 30″ W	30			1	U. S. R. S. Corwin, 15823.
	60° 22′ N., 168° 45′ W	25.5			1	Lieut. Geo. M. Stoney, 15834.
1068	62° 39′ N., 177° 05′ W	55	Clay		1	Riksmuseum, Stockholm, Vega expedition.
1049	Port Clarence, Alaska	4–6	Stones		1	Do.
1072	Off Bering Island	65–75			1	Riksmuseum, Stockholm, Vega expedition, *acervata* from this station.
1046	Mouth of St. Laurence Bay, Siberia	4–6	Stones, algae		1	Riksmuseum, Stockholm, Vega expedition, intermediate with *acervata*.

LEPTASTERIAS POLARIS KATHERINAE (Gray)

Plate 33, Figures 1–6; Plate 34; Plate 36, Figure 1; Plate 41

Asterias katherinae Gray, Ann. and Mag. Nat. Hist., ser. 1, vol. 6, 1840, p. 179; Synop. Starfishes Brit. Mus., 1866, p. 2.—Perrier, Révision des Stellérides, 1875, p. 67.—Verrill, Shallow-water Starfishes, 1914, p. 112, pl. 51, figs. 1, 2; pl. 52, fig. 1; pl. 83, fig. 1.

Asteracanthion katherinae Müller and Troschel, System der Asteriden, 1842, p. 19.—Dujardin and Hupé, Hist. nat. Zooph., Echinodermes, 1862, p. 339.

Asterias douglasi Perrier, Révision des Stellérides, 1875, p. 69.

Asterias dubia Verrill, Amer. Nat., vol. 43, 1909, p. 545.

Pisaster grayi Verrill, Shallow-water Starfishes, 1914, p. 97. See Fisher, Ann. and Mag. Nat. Hist., ser. 9, vol. 17, 1926, p. 556.

Leptasterias polaris katherinae Fisher, Ann. and Mag. Nat. Hist., ser. 9, vol. 12, 1923, p. 599.

Asterias katherinae was very briefly described by Gray from specimens stated to have been collected at the mouth of the Columbia River. The original specimens are eight in number and were presented to the British Museum in 1838 by Lady Katherine Douglas. They were entered in a preliminary register as coming from Labrador. Doctor Gray, however, gives "North America, mouth of the Columbia River" as the locality and, since another specimen has been taken in the Gulf of Georgia, there can be little doubt that the entry made in 1838 was incorrect and that Doctor Gray was right.

Through the courtesy of Sir S. F. Harmer, formerly director of the British Museum (Natural History), and of Dr. R. Kirkpatrick, then in charge of the collections of Echinoderms, I received for detailed study four of Gray's types. Doctor Kirkpatrick had photographs made of the others, and forwarded me notes on the specimens. Subsequently I visited the British Museum and examined all of the types. At his request, one of the specimens having the original register number attached, namely, 38.7.15.107, has been formally designated as type of the species.

It is necessary to correct an erroneous impression, due to a statement by Perrier, that the actual types of Gray are not known with certainty. Perrier (1875, p. 67) says: "Il est assez difficile de savoir avec précision ce que Gray a voulu designer sous le nom d'*Asterias Katherinae*."

There is no shadow of doubt concerning the eight original specimens. They are all identifiable with certainty. Five have the original register numbers glued to them. Of the other three, two without either register numbers or Gray's original small letter, had labels, "*As. katherinae*" in Gray's writing. The remaining one alone without number, letter, or original name label of Gray was labeled (subsequently, possibly by Professor Bell) *A. katherinae*, mouth of Columbia River (No. 38.7.15.111). So it too must be one of the original eight.

In a manuscript list Gray entered the eight specimens as follows; the asterisk denotes specimens which were sent to me.

a. Five-rayed 38.7.15.108 (a true *katherinae*).
b. * Six-rayed 38.7.15.110 (smallest specimen; type of *A. douglasi* Perrier).
c. Six-rayed 38.7.15.104.
d. Six-rayed 38.7.15.105.
e. Six-rayed 38.7.15.106 ("*As. katherinae* Gray").
f. * Six-rayed 38.7.15.107 (type).
g. * Six-rayed "variety" (38.7.15.109) ("*As. katherinae* Gray").
h. * Six-rayed "variety" (38.7.15.111) ("cotype" of following description).

The numbers of *e*, *g*, *h*, were lost and were replaced in 1920 by Doctor Kirkpatrick; *h* was without any label but by a process of elimination is almost certainly one of the "variety" specimens. I have examined all of the specimens; the last is certainly a true *katherinae* and is referred to as a "cotype" in the following description.

Although No. 108 is a 5-rayed specimen and was labelled "*Asterias troscheli*" by Bell or Perrier, it is a true *katherinae*.

All the specimens were dried without having been cleaned, so that the spines to some extent are obscured by dried slime, sand, and sawdust, while the tube-feet are more or less plastered over the oral and adambulacral armature. It was a simple process to clean the type and specimens *b* and *h*. One ray of *h* was detached at the base for a study of the skeleton and to determine the position of the gonads.

Although Perrier (1875, pp. 67, 68) redescribed *A. katherinae*, apparently from the authentic specimens of Gray, he mentioned two 5-rayed examples. One of the 6-rayed specimens he described as *Asterias douglasi*, stating that there were also several specimens without locality in the Museum d'Histoire Naturelle (p. 69). The British Museum specimen (No. 110 of the foregoing list) was considered the type. The dimensions (R 70 mm., r 17 mm.) and description given by Perrier apply to it. It seems to me to be typical *katherinae* and certainly one of the original series since there is clinging to it the same kind of sand that is attached to the other examples. *Asterias douglasi* is therefore a synonym of *katherinae*. (Pl. 33, figs. 3, 5.)

In his description of the specimens of *katherinae* Perrier (p. 68) writes that the adambulacral spines are in a *single* series along the furrow margin. This is simply an error of observation, for his description was not taken from one but from several specimens, since he says: "Voici la description *des individus* auxquels doit être réservé, selon nous, le nom d' *Asterias katherinae*, la description de Gray ayant évidemment été faite d'après eux." In none of the authentic examples are the spinelets in a single series. This mistakes was unfortunate since it led Verrill to infer the existence of a second set of 6-rayed asterids having monacanthid adambulacrals, which he named *Asterias dubia* (1909, p. 545), later *Pisaster grayi* (1914, p. 97). No such second set exists, however, so that these names must be regarded as synonyms of *katherinae*.

Diagnosis.—Rays six; exceptionally five; size rather large. Closely resembling a thick-rayed *L. polaris* having irregularly and well spaced abactinal spines. Differing from *L. polaris acervata* in lacking convex groups of abactinal spines, and from forma *aphelonota* in having smaller straight pedicellariae and more widely spaced abactinal spines. Abactinal spines very irregularly arranged, sparser than in *acervata*, clavate, subcapitate, with the ends finely grooved; carinal spines not clearly differentiated; a single row of superomarginal, one of inferomarginal, and two of actinal spines, subcylindrical, often slightly clavate, robust; adambulacral spines normally one and two alternating, the furrow spines of diplacanthid plates slenderer than the others, and more advanced into furrow than that of monacanthid plates; very numerous small ovate or broadly lanceolate straight pedicellariae. R = 4.5 to 5.3 r.

Description.—The measurements of the type, No. 38.7.15.107, British Museum Register, are as follows: R 145 mm., longest ray and 137 mm. shortest ray; r 27 or 28 mm.; R = 4.9 to 5.3 r; breadth of ray at widest part, just beyond base, 28 to 31 mm.; height of disk, 20 mm. Measurements of cotype No. 38.7.15.111: R 148 to 155 mm.; r 33 mm.; R = 4.5 to 4.7 r; breadth of ray at widest part near base (ray depressed in drying) 33 to 35 mm.

The abactinal spines are numerous, not large, unequal, and arranged irregularly on the irregular reticulum of dorsal plates. They are shortest on the radial area, where the primary or principal spines are about 1 to 1.8 mm. long, increasing gradually to 2 or 2.5 mm. on the dorsolateral surface of ray. The irregularly arranged radial plates, and to a less extent the adradial plates, carry, in addition to the principal spine, which is thick-set, clavate or capitate, and longitudinally striated at the globose or subtruncate tip, three to seven smaller but usually relatively slenderer accessory spines, not uniform as to size or arrangement. These are, when perfect, also somewhat grooved at the top and beset with unequal points. Some of the radial plates have eight or nine subequal spines of the minor size, in a group, or in transverse lines, and connecting plates also bear a few spines of secondary size. The dorsolateral plates, however, usually have but one spine, or at best only one or two small accessories. In the cotype the abactinal spines are slightly stouter and rather less numerous than in the type specimen. The maximum number on the radial plates is nine, but is usually only five or six. It is only on plates where the spines are numerous that there is any suggestion of the acervate or heaped arrangement characteristic of *acervata*. Even this suggestion is not at all striking or conspicuous. Just above the superomarginal plates there is a noticeable zone free from spines on the proximal half of the ray.

The superomarginal spines, proximally one to a plate, and separated for about the length of the spines, form a regular lateral row, which rises to the level of the abactinal surface at the interbrachial angle so that here the intermarginal zone widens abruptly. The spines are stout, subcylindrical, either slightly tapered or slightly clavate, blunt, about 3 mm. long, and a little weaker than the nearest dorsolateral spines. There are about 50 superomarginal plates, and those near the end of the ray usually bear two or three stubby tubercles similar to the abactinal, while sporadically a proximal plate carries two spines.

The inferomarginal spines are very similar to the superomarginals though a shade longer, and a few of the proximal plates quite irregularly carry two or even three spines; the distalmost plates usually bear but one. The intermarginal zone is conspicuous and at the broadest part of the ray is about twice as wide as the length of the superomarginal spines. Just below the inferomarginal spines which are on the actinolateral angle or curvature of the ray, is another narrower, spineless zone, and then follow two series of actinal spines, somewhat stouter than the inferomarginals the outer of which reaches the end of the arm, while the inner extends about three-fourths the length, measured on side.

The adambulacral plates follow closely after the inner actinals and are rather crowded, there being about 33 to 10 inferomarginal plates at the base of the ray. The normal arrangement is one and two spines to a plate alternating, the single spine standing in line with the interval between the two of adjacent plates. The inner spine of these alternate plates is slenderer than the others, tapered and is carried on the angle between the actinal and furrow surfaces of the plate. The furrow spine is 2.8 to 3 mm. long, the others, which are untapered to very slightly so, a trifle flattened, and blunt, are 3.2 to 3.8 mm. long. The first 10 or dozen plates beyond the adoral carina of contiguous adambulacrals usually carry two spines each, after which the regular arrangement becomes fixed.

The mouth angle is formed of the mouth plates followed by four pairs of contiguous adambulacrals, each of the latter carrying a single spine. This oral carina is rather narrow, and its length about equals the width of actinostome. The entrance to the furrow is narrow. The mouth plates bear each three spines, a somewhat flattened truncate or round-tipped one directed over actinostome, a small one guarding the mouth of furrow and carried on the inner furrow angle of plate, and a much longer tapered suboral 3.5 to 4.5 mm. in length. (Pl. 34, fig. 3.)

The papulae could be determined by softening a ray of the cotype. Abactinally at the base and middle or ray there are 15 to 25 in the larger skeletal meshes, and 10 in the small; in the intermarginal meshes, 6 to 10; in areas between the inferomarginal and first actinal plates, five or six; between the two series of actinal plates, three or four; and adjacent to the adambulacral plates, proximally two or three.

Two kinds of pedicellariae, straight and crossed, are present. The straight pedicellariae are numerous, small, and practically all of one form, ovate or broadly lanceolate, obtuse, as seen in profile. They are thickly scattered all over the abactinal surface, intermarginally, actinally, and, with small crossed pedicellariae, form half wreaths on the inferomarginal, actinal, and subambulacral spines, and conspicuous clusters on the furrow spines (of alternate plates). A few quite small ones are found on the furrow face of the adambulacral plates, and clusters are present on all of the mouth spines. The largest are found in the intermarginal channel where they are commonly 0.5 to 0.65 mm. long at the base of ray. Those on the actinal plates and spines are a little smaller, while the numerous adambulacral ones are 0.3 to 0.375 mm. long. The abactinal straight pedicellariae are 0.3 to 0.5 mm. long as a rule. As shown by the figures, these pedicellariae are of a simple generalized form with rather irregular minutely denticulate edges to the jaws. No trace of specialized unguiculate pedicellariae could be discovered.

The crossed pedicellariae are quite small, mostly between 0.2 and 0.3 mm. in length and form clusters or wreaths around the base of the abactinal and superomarginal spines, and are scattered also on the surface of plates at a distance from spines. Mingled with the straight pedicellariae, they form half-wreaths or bouquets on the outer side of the inferomarginal and actinal spines, and a few are found in the adambulacral clusters, where the straight pedicellariae greatly predominate. The exact form of these pedicellariae is best appreciated from figures as there is some variation. (Compare with pedicellariae of *L. polaris*, *L. polaris acervata* and formae.)

The madreporic body is conspicuous, 5.5 mm. in diameter, very slightly convex, with rather fine branched, radiating grooves or striae. The center of the madreporite is about 0.4 r from the center of disk.

Anatomical notes.—The cotype was softened for cleaning and one ray removed. The gonads although shrunken appear to have been voluminous. They are attached to the interbrachial septum about midway between the dorsal and ventral surfaces of the body, considerably below the level of the upturned line of superomarginal plates. The gonoduct appears to turn downward but whether it opens intermarginally or actinally can not be determined.

The dorsal skeleton, that is, all the plates above the superomarginals, is very irregularly reticulate. The primary spine-bearing plates are usually irregularly three or four lobed. These are rather outnumbered by elongate or faintly lobate plates of diverse sizes which might roughly be classed as connectives. A portion of the abactinal skeleton from the radial region of the cotype is figured on Plate 34 Figure 2. This is from the coelomic side. Just above the superomarginal plates (pl. 34 fig. 1*s*) is a row of elongate transversely oriented connectives, between which are large papular areas generally well supplied with straight pedicellariae. The superomarginal, inferomarginal, and both series of actinal plates are regularly four lobed and are imbricated in transverse as well as longitudinal series. Internally, slender, compressed plates bind the superomarginals to the plates above (*i*) and to the inferomarginals, either directly or by a second similar plate, closely joined in vertical series; while one or two similar, smaller plates may continue the series across the actinal plates, attached to their dorso-ventral lobes, which are themselves somewhat carinate on the coelomic side. These plates thus form ridges separating shallow pockets along the ventrolateral and lateral wall of the ray, into which the viscera are normally crowded.

The ambulacral ossicles are not especially crowded, there being 12 in the space of 10 mm. counting from the outer end of the contiguous oral adambulacral plates (oral carina). The form of the pores is shown by the figure. (Pl. 34, fig. 1, *am.*)

Variations.—The smallest specimen of Gray's type series is "37*b*," or No. 110, which has R 70 mm. (longest ray), r 16.5 mm. (Perrier gives 17 mm.), breadth of ray at base, 15 mm. It differs from the type and cotype in having a more closely knit skeleton, there being fewer and shorter secondary connecting plates. As a result, the spiniferous primary plates are less widely separated, the papular areas are relatively much smaller than in the type, and the spines are very much closer together. The median radial plates are larger than the other dorsal plates and the series is clearly distinguishable both by reason of the larger size of the plates and by their more numerous, close-set, capitate spinelets. In form these might be described as very depressed globose with numerous, fine, rather deep vertical, or meridional, striae, and there are 12 or even more to the larger plates, but only five or six are of major size, the others being crowded on the periphery. This number is greater than is to be found on similar plates of the type. The proximal superomarginal plates carry one or two, sometimes three, longer, clavate spines, while the plates of the outer half of the ray generally have three or four spines subequal to the abactinals, in a transverse, somewhat arcuate, series. The inferomarginal spines, one or two to a plate, are slightly longer and heavier than the superomarginals (especially distally is the difference conspicuous) while the outer actinal spines are subequal to the inferomarginals. The inner series is only starting, and consists of a few smaller spines at the base of the ray. There are generally two adambulacral spines to each plate, or distally two and one alternating. The pedicellariae (pl. 33, figs. 3, 5) are essentially like those of the larger specimens. The subambulacral crossed pedicellariae have the characteristic longer serrulate straight-edged jaw. (Fig. 3*a.*)

As previously mentioned, this specimen presents a much more compact appearance than does the type. Apparently increase in stature is due primarily to an increase in the size and number of secondary connecting plates, resulting in a separation of the primary spine-bearing plates and a generally more open skeleton. The Gulf of Georgia specimen is less compact than No. 110, but more closely knit than the type.

This is the specimen described by Perrier (1875, p. 69) as *Asterias douglasi.* I have seen a very similar specimen of *L. polaris borealis* Perrier from Labrador (U. S. Nat. Mus 1376). The resemblance is uncanny.

Professor Verrill (1914, p. 112) has described and figured the specimen from the Gulf of Georgia (Museum of Comparative Zoölogy, No. 1181). Through the courtesy of Dr. H. L. Clark I have received this specimen for study. I think it is referable to *Leptasterias p. katherinae,* although as might be expected from its smaller size and different habitat, it is not precisely like the type. Its dimensions are: R 85 mm., r 18 mm., R = 4.7 r; breadth of ray at the widest part, just beyond base, 19 mm. The rays are not so inflated as in either the type or specimen *h*, and there is no zone above the superomarginals of conspicuous width at the base of ray free from spines. The abactinal spines are typical in form and arrangement and are relatively about the size of those of the cotype, and a trifle larger than those of the type. The superomarginal spines are stouter and a little longer than the adjacent abactinal spines, whereas in the type and cotype the adjacent abactinal spines are a trifle heavier. The distal superomarginals bear a transverse series of three or two spines, which is typical, and occasionally a proximal plate carries an extra spine, or a group of three smaller spines. The intermarginal channel is narrower, as is also that below the inferomarginal spines. The actinal plates are in two series and the spines are a little thicker than the inferomarginals, clavate and obtuse or pinched at the tip. A few of the plates bear a group of three or four smaller spines in place of the single normal spine.

Professor Verrill writes: "The adambulacral spines are unusually numerous, crowded in three or more rows. They stand mostly two on a plate, but often there are three on part of the plates, or alternately two and three" (1914, p. 113). This is misleading since plates with three spines occur very rarely. After considerable search I found one on the outer third of the ray, and the third spine is small and interpolated between the two regular spines. The mistake probably arose from counting the spines of two consecutive plates, since the armature is crowded. Taking at random one furrow margin and commencing with the first plate, the spines per plate are as follows: five with one spine, then eight with two, then 1 2 1 2 2 1 2 1 2 1 2 2 1 2 2 2 1 2 2 2 1 2 2 1 2 2 2 1 2 1 2 1 2 1 2 1 2 2 2 2 1 2 1 2; then 32 plates with alternately 2 and 1; then 3 1 2 1 2 2 1 1 1 2, etc.

The adambulacral spines are therefore normal for the species. The mouth plates may have a second small spine on the actinostomial margin adjacent to median suture.

The pedicellariae, both straight and crossed, are like those of the type in form and are similarly distributed. The abactinal crossed pedicellariae are about 0.225 mm. long while the straight are usually 2 or 2.5 times as long. The latter are very numerous, and the largest about 0.65 mm. in length are found laterally near the base of the ray. The abactinal pedicellariae are figured. (Pl. 33, figs. 2, 6.) The crossed pedicellariae seem to have a few more teeth than in the typical form.

Leptasterias p. katherinae seems destined to cause confusion. Verrill (1914, p. 112) describes and figures this specimen, No. 1181, as *A. katherinae*, but later in the same work, p. 178, records it as *Orthasterias merriami* and figures (pl. 75, figs. 1–1*d*) the dorsal, marginal, and adambulacral spines, as of *merriami*. The specimen is not *merriami*, however. I suspect there is a mistake in this plate. Figure 1, *a*, *b*, and *c*, and Figure 1*c* do not represent typical ordinary dorsal spines of No. 1181 and would certainly mislead anyone attempting to use the figure for *katherinae*. The typical dorsal spines are similar to those figured in this work (pl. 33, fig. 1*f*), being stubby, clavate to subcapitate and grooved at the tip. They do not carry straight pedicellariae on the sides, as shown in Verrill's Plate 75, Figures 1, *a*, *b*.

Type.—No. 38.7.15.107, British Museum (Natural History). Cotypes 38.7.15.104, 105, 106, 109, 110, 111. The last, kindly presented by the authorities of the British Museum will be deposited in the United States National Museum.

Type locality.—Mouth of the Columbia River.

Distribution.—Mouth of the Columbia River; Gulf of Georgia, Washington.

Specimens examined.—Nine, as follows: Mouth of the Columbia River, the type series from the British Museum (Natural History), Lady Katherine Douglas, eight specimens.[24] Gulf of Georgia, Washington, No. 1181, Museum of Comparative Zoölogy, one specimen.

LEPTASTERIAS COEI Verrill

Plate 29, Figures 3, 3*a*, 5, 5*a*

Leptasterias coei VERRILL, Shallow-water Starfishes, p. 123, pl. 9, fig. 1; pl 17, figs. 1, 2 (young).

Orthasterias merriami VERRILL, Shallow-water Starfishes, 1914; p. 177, pl. 18, figs. 4, 5; pl. 19, figs. 1, 2; (pl. 75, figs. 1–1*d* refer to *L. katherinae*).

Diagnosis.—Resembling a large 6-rayed *L. tenera* (Stimpson) with fewer, coarser, and shorter spines. R 112 mm., r 17 mm.; R = 6.5 r; rays slender gradually tapered, well arched; abactinal spines very well spaced, coarse, cylindrical, blunt, surrounded by broad mats of pedicellariae; superomarginals conical, inferomarginals and one or two series of actinals, longer, subcylindrical, terminally compressed, blunt or subtruncate; adambulacrals proximally monacanthid or diplacanthid; over most of ray alternately monacanthid and diplacanthid.

Description.—Dorsal ossicles broad, strong, convex, and firmly united, with small papular spaces intervening; spines well spaced, conspicuous, stout, but not very long, cylindrical or a little tapered, obtuse. They stand singly on the ossicles and are surrounded at base by large wreaths of pedicellariae. They form an irregular radial row and two or three indistinct or imperfect rows each side of it, with smaller spines interpolated. The upper and lower marginal spines form equal regular rows, one spine on each plate. These spines are larger and longer than the dorsals, mostly conical and subacute; those of the lower series are distinctly longer, especially near the base of the rays. Those in the upper row bear large dense, complete wreaths of pedicellariae; those in the lower row have them only on the upper side. The two rows are separated by a naked channel which becomes wide proximally and bears large, ovate major [straight] pedicellariae, clusters of minor [crossed] pedicellariae, and a row of papular pores. At the base of the rays are two close rows of actinal spines, similar to the lower marginals. Of these the outer row is close to the marginal, but with small intervening papular pores, and it extends nearly to the end of the ray. Its ossicles are rounded, convex, and nearly as large as the marginals. The inner row extends about half the length of the ray. Many of the actinal spines are flattened or acuminate at the tip; others are obtuse.

The adambulacral spines on the middle and distal plates stand one or two to a plate, alternating irregularly, but on the proximal fourth of the ray they are mostly one to a plate. They are rather stout, shaped like the actinal spines, but smaller and shorter, varying in size, mostly obtuse, but the smaller ones often acute. Toward the mouth they become longer, more slender and subacute. The peroral [actinostomial] spines are large and strong and nearly meet over the mouth. The two apical peroral spines, which are much stouter than the adorals, but not so long, are straight, tapered, a little flattened, obtuse; the smaller side-spine is about half as long, but of the same shape. They bear small, ovate, forficulate [straight] pedicellariae. The epiorals and adorals are similar in form, distinctly longer than those farther out, slender, terete, and evenly tapered. The adoral carina consists of three pairs of closely contingent plates besides the orals. Large ovate, major pedicellariae occur between the interactinal spines. (Verrill, pp. 177, 178, *O. merriami.*)

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[24] The types have considerable sand adhering which might be described as dark gray, as it consists of blackish and translucent (quartz ?), somewhat water-worn grains. Possibly it is only beach sand.

I have examined the type of *Orthasterias merriami* figured by Verrill on Plate 18, Figures 4 and 5, and the cotype, Plate 19, Figures 1 and 2 (Verrill, 1914). The pedicellariae and spines figured on Plate 75, Figures 1 to 1*d*, do not belong to a specimen of this species but to *L. katherinae*. The specimen in question, No. 1181, Museum of Comparative Zoölogy, I have examined. It appears to be true *katherinae* and it is so listed (under *Asterias*) by Professor Verrill (p. 112). The record of *merriami* from the Gulf of Georgia, based upon the same specimen, is therefore an error (Verrill, p. 178).

I have quoted Verrill's description of the type of *Orthasterias merriami* because my three specimens from Shelikof Strait are smaller, and were taken at some distance from the type locality, Glacier Bay.

The superomarginal spines of the type are slender-conical (1.75 mm. long) and are noticeably smaller than adjacent dorsolateral spines, while the inferomarginals (about 3 mm. long) are not at all conical but rather compressed-cylindrical, only slightly tapered, with a blunt or subtruncate tip. The actinal spines have the tips more compressed and often chisel-shaped or slightly gouge-shaped.

In the cotype (Berg Bay, Glacier Bay) the proximal adambulacral plates are nearly all diplacanthid, the furrow spine of alternate plates being slenderer, and set a little farther into the furrow. Near the end of the ray the plates are alternately monacanthid and displacanthid. The abactinal spines show a slight fluting, well marked on the proximal carinals. It is only faintly visible on some of the spines of the type, which, however, is not so well preserved.

Crossed pedicellariae are very numerous and occur in broad bands surrounding the abactinal and superomarginal spines as well as in thick clusters on the outer side of the inferomarginal and actinal spines. Mixed with straight lanceolate pedicellariae they form small clusters on the adambulacral spines. Between the primary abactinal spines there are numerous small clusters attached to smaller plates while secondary abactinal spinules, smaller than the conspicuous primaries, carry correspondingly small wreaths. The abactinal pedicellariae measure 0.30 or 0.31 mm. long. (Pl. 29, fig. 3.) Those of the adambulacral plates are of about the same size but somewhat different form, as is usual. (Pl. 29, fig. 3*a*.)

The straight pedicellariae (pl. 29, figs. 5, 5*a*) are small (about 0.5 mm. long) compressed, ovate, or broad-lanceolate. They may have even more compressed jaws than those figured and are very diminutive as compared to the broad-toothed ones of *L. coei truculenta*. The largest specimen from Shelikof Strait (station 4292) measures R 63 mm., r 12 mm., the rays being slender, tapered, and of about the same form as those of the type of *merriami* figured by Verrill.

The pedicellariae have the characteristic form, but the straight are slightly longer (0.7 mm. in the intermarginal channel). Some of them have two or three teeth, although the jaws are narrow. None of the intermarginal or actinal straight pedicellariae approach the large size and breadth of valve characteristic of *truculenta*. The abactinal straight pedicellariae are quite typical, of a compressed broad-lanceolate or ovate form, with only a slightly crenulated distal margin. The abactinal straight pedicellariae, like those of the type, measure about 0.28 mm., while the adambulacral measure 0.25 mm.

These specimens have the characteristic heavy apical oral spine, each angle pair with a small companion at each side. The first 9 or 10 adambulacrals are mostly monacanthid, the rest alternating monacanthid and diplacanthid. There is a single row of actinal spines extending about half the length of the rays and the carinal spines are conspicuously heavier than the dorsolaterals. Both sorts are subcylindrical, not long, with rounded very finely striate tips. The coarsely striated madreporite is slightly adcentral to the middle of r.

The type of *L. coei* was taken in Berg Bay, 10 fathoms, and is figured by Verrill (1914) on Plate 17, Figure 1; the cotype of *Orthasterias merriami* was taken in 10 fathoms, Berg Bay (it is labeled "Berg Bay, Glacier Bay"). Another smaller specimen of *coei* is figured as the type on Plate 9, Figure 1, and as cotype on Plate 17, Figure 2. Unfortunately, neither specimen of *coei* can be found in the Yale Museum.

I think *L. coei*, the type of which measured only R 30 mm., is undoubtedly a young form of the cotype of *O. merriami*. The cotype of *merriami* seems not distinguishable specifically from the type (from off Juneau, Alaska, 20 fathoms). If the types of *coei* are really lost, as seems probable, the species will have to rest upon the type of *merriami*. The name *coei* has page priority over *merriami*.

Type.—Yale Museum (probably lost).

Type locality.—Berg Bay (Glacier Bay), Alaska, 10 fathoms (Harriman Alaska expedition).

Distribution.—Juneau to Shelikof Strait, Alaska, 10 to 102 fathoms.

Specimens examined.—Off Juneau, 20 fathoms (type of *merriami*). Berg Bay, Glacier Bay, 10 fathoms (paratype of *merriami*). Station 4292, Shelikof Strait, 94 to 102 fathoms, blue mud, fine sand, bottom temperature 39.8° F. (three specimens).

LEPTASTERIAS COEI TRUCULENTA, new subspecies

Plate 24, Figure 3; Plate 25; Plate 26; Plate 29, Figures 1, 2, 4

Diagnosis.—Rays six; size large; in general appearance similar to *L. coei* (adult) but with more numerous abactinal spines, on the average longer; without conspicuous interspinal clusters of crossed pedicellariae, either alone or surrounding small secondary spinelets (these having developed into primary spines); with numerous very large abactinal, intermarginal, and actinal straight pedicellariae, having oblong to squarish coarsely toothed jaws, in addition to smaller compressed ovate ones; abactinal spines finely to coarsely fluted. Rays long, rather slender, arched in alcoholic specimens; disk small; interbrachial angles very sharp; skeleton well covered by opaque skin, and abactinal spines with a thick pad of pedicellariae which in alcoholic specimens frequently touches that of neighboring spines; spines upright bristling, rather uniformly spaced, robust, the abactinal without definite serial order, but the marginals and actinals (one to three series) in regular, rather close series. R 220 to 225 mm., r 30 mm., R = 7.3 r; breadth of ray at base 30 mm. (type). R 121 mm., r 19 mm., R = 6.3 r; breadth of ray at base 20 mm.; station 4777.

Description.—Abactinal spines well spaced, prominent, cylindrical at the base, with a slightly swollen, longitudinally striated conical or acorn-shaped round tipped to subacute distal half. The carinals are usually distinguishable by being a little closer together rather than by superior size; but often they are not distinguishable from the other spines. The relative thickness and form of the spines is decidedly variable. Sometimes they are fairly short and robust, the acorn-shaped portion occupying almost the entire length; or the spine is distinctly styliform. The large type from Captains Bay has coarsely grooved subacute, unusually widely spaced spines which in the dried condition appear slender-conical. The plates are distinctly convex, which adds to the apparent length of the spines of this species. The dorsolateral spines are not in regular longiseries, not in quincunx, but for short distances sometimes stand in longiseries or oblique series. There are the equivalent of about three to five longiseries in grown specimens.

Superomarginals cylindrical, tapered, bluntly pointed, less often obtuse, sometimes asymmetrical or even a trifle bent at the tip, which is also usually a trifle swollen. The spines stand regularly one to a plate, are a little longer than the abactinals, and the series curves upward to the abactinal surface at the interbrachial angle. Intermarginal channel narrow, definite, very well marked.

Inferomarginal spines still longer than the superomarginals (3 to 5 mm. in medium-sized to large specimens), cylindrical at base, tapering on outer half, and finally at the tip sometimes decidedly compressed, blunt or subtruncate. Most of the terete spines are bluntly pointed.

Actinal spines in one to three series (according to size), similar to the inferomarginals with which they also form transverse combs, the narrow intervals between the series being subequal. In average sized specimens, the outer row of actinal plates extends to within a short distance of the ray-tip while the second series reaches upward of two-thirds the length of ray (R = 124 mm.). A specimen from station 4777, with R 114 mm., has only a single series of actinal spines, which is exceptional. In the very large type from Captains Bay there are three series of actinals to the middle of ray, and two nearly to the end. (Pl. 26, *a*,[1] *a*,[2] *a*.[3])

The abactinal skeleton is irregular, the plates overlapping broadly by their three or four usually unequal asymmetrical lobes. The marginals and actinals, on the contrary, build very regular series and imbricate longitudinally and transversely very strongly. The entire width occupied by the actinal and marginal plates is much less (about two-thirds) than the breadth of the dorsolateral area. The marginals and actinals are proximally asymmetrically four lobed, and beyond the proximal fourth of ray become longer than broad, and appear superficially more often three than four lobed. The central portion of the plates is strongly convex.

Papular areas relatively small (those just above superomarginals largest), three to six, or more papulae to an area abactinally where they are not conspicuous owing to the thick mats of crossed pedicellariae surrounding spines. There is an intermarginal series of areas, and one to four actinal series, proximally, to one to three distally according to size of specimen.

Adambulacral plates compressed, about 33 to 10 inferomarginals at middle of ray. The armature is ideally alternately monacanthid and diplacanthid, but the regularity is disturbed at base of ray where the plates of adoral carina and a few following are usually monacanthid. In the very large type most of the plates are diplacanthid. The furrow spine of diplacanthid plates is shorter, slenderer, and more obviously tapered than the others which are terete, slightly tapered near the blunt tip, sometimes slightly compressed. In nicely killed specimens the spines appear to form three longiseries at margin of furrow since the slenderer furrow spine of diplacanthid plates is advanced into the furrow; its companion spine forms the outer series, the middle being composed of the single spines of alternate monacanthid plates. Adoral carina composed of three or four contiguous postoral adambulacrals, the single spines of which are appreciably longer than those following.

Mouth plates with a conspicuous apical, tapered, blunt or subacute spine (with a small lateral companion) longer than the median suture, and a long slender tapered suboral spine almost identical with the first few adambulacral spines, though a trifle longer.

Crossed pedicellariae (pl. 29, figs. 1, 1*a*–1*e*) are very numerous, 0.29 to 0.31 mm. long, in conspicuous wreaths (one to four tiers of pedicellariae broad) surrounding abactinal and superomarginal spines, and scattered singly or in groups of two or three among the papulae (type); in fairly large clusters on the outer side of inferomarginal and actinal spines (along with straight pedicellariae in largest examples); mixed with compressed broadly lanceolate straight ones, in clusters, on the outer side of adambulacral spines. The last differ in form from the abactinal, being slightly smaller (0.27 mm.) with a larger terminal portion to jaw, as seen in profile. (Pl. 29, figs. 1*a*, 1*d*.)

Straight pedicellariae numerous, large. (Pl. 29, figs. 4, 4*a*–4*f*.) The abactinal vary greatly in size and form, some having broad squarish dentate jaws, others narrower dentate jaws with two or three teeth; still others are small, compressed, ovate, edentate, as in *coei*. The intermarginal and axillary channels are conspicuously provided with broad-valved toothed pedicellariae (upward of 1.25 mm. broad and 1.5 mm. high), veritable giants compared with the same armature of *coei*. Similar but somewhat smaller ones are found among the actinal spines, where also there are still smaller, compressed, ovate or broad-lanceolate pedicellariae without obvious teeth, together with intermediate stages between the two. Some of the latter migrate upon the inferomarginal and actinal spines in the largest example (Captains Bay). The largest pedicellariae are much broader than the spines in *small and medium-sized* examples and vary somewhat in number, but are always numerous. Ovate compressed pedicellariae occur abundantly on the adambulacral and oral spines, and very small ones singly or in clusters on the furrow face of the plates. The difference in size between these and the intermarginals is enormous.

Madreporic body conspicuous with fairly coarse striae, situated at nearly mid r.

Tube feet fairly large, crowded in four series. Actinostome small, rather sunken.

Young.—A specimen with R 28 mm., was taken with adults at station 4777, and resembles the larger examples, but has only a few actinal spines at base of ray. The characteristic large pedicellariae are well developed. The next size with R 67 mm. is adult, in respect to spines and pedicellariae.

Anatomical notes.—The gonads (not mature in any example examined except the large one from Captains Bay) are attached to the interbrachial septum on a level with the inferomarginal plates, just a few millimeters adcentral to the interbrachial angle. The duct passes between the dorsal lobes of two inferomarginal plates, turns distad and slightly downwards, to open in the axillary channel on a level with the inferomarginal plates, or slightly below. There are two pulpy prominences close to the innermost (reduced) inferomarginal spine and usually guarded by large straight pedicellariae, which mark the opening. They are situated on the actinal surface, as viewed from below, but close to the margin. (Pl. 26, *g*.)

The interbrachial septum is firm and thick (calcified) and extends about two-thirds of r toward the center of disk.

Type.—Cat. No. E 1492, U.S.N.M.

Type locality.—Ridge, Captains Bay, Unalaska, 1880. W. H. Dall, No. 1749 (1 specimen).

Distribution.—From Unalaska to Semisopochnoi Island, Aleutian Islands.

Specimens examined.—In addition to type, 17 from: Station 4777, Petrel Bank, Bering Sea, northeast of Semisopochnoi Island, Aleutians, latitude 52° 11′ N., longitude 179° 49′ E., 52 to 43 fathoms, fine gravel, three specimens.

Station 4779, same locality, 54 to 56 fathoms, broken shells, pebbles, sand, 14 specimens.

CAMTSCHATICA SECTION

The species of this section are, so far as known, restricted to the coasts bordering the north Pacific and southern Bering Sea. On the Asiatic side they have not been recorded south of the Kuril Islands and on the American coast south of Santa Catalina Island, Calif.

All the forms are very variable. Species lines are extremely indistinct, sometimes hardly recognizable. For this reason descriptive terms have to be handled in a relative manner, and figures are indispensable. Most of the species are a composite of small varieties or formae. Some of these forms perhaps represent incipient species. Most of the species have paucispinous and multispinous phases, as well as coarse-spined and slender-spined formae; rays slender, medium, or robust. Various combinations of these extremes and their seemingly endless intermediate stages occur. Even with a large series it is not possible to satisfy oneself of the systematic position of every specimen. It is not expected therefore that this treatise will suffice to allocate every isolated specimen of which the name is required. Nor do I admit that a few apparent exceptions will invalidate the whole systematic arrangement. The careful investigator will find many of his perplexities anticipated in the following pages. I have found this group more difficult even than the *polaris* section.

The following is a list of the names which have been applied to or intended for species of this group, in order of their priority.

Asterias camtschatica Brandt, Prodromus, 1835, page 270. Kamchatka. This appears clearly to apply to the common 6-rayed Kamchatkan *Leptasterias*. *Leptasterias camtschatica.*

Asterias hexactis Stimpson, 1862, page 272. Puget Sound. Types in the United States National Museum; studied. *Leptasterias hexactis* forma *hexactis*.

Asterias aequalis Stimpson, 1862, page 273. Monterey, Calif. Type in United States National Museum; studied. *Leptasterias aequalis.*

Asterias vancouveri Perrier, 1875, page 64. Puget Sound. Type in British Museum; studied. *L. hexactis vancouveri.*

Asterias macropora Verrill, 1909*a*, page 65, Figure 10. Alaska (see below). Name has status only by bare technicality. *Stenasterias macropora*.

Asterias epichlora Verrill (not Brandt), 1909*b*, pages 544, 549. See below.

Asterias epichlora variety *alaskensis* Verrill, 1909*b*, page 549. No type locality; no type. See below.

Asterias multiclava Verrill, 1914, page 114. Bering Island, Commander Islands. Type in United States National Museum; topotypes studied. Synonym of *L. camtschatica*.

Leptasterias aequalis variety *compacta* Verrill, 1914, page 130. Pacific Grove, Monterey Bay, Calif. Type in Yale Museum. Synonym of *L. aequalis* forma *aequalis*.

Leptasterias aequalis variety *nana* Verrill, 1914, page 132. No type or type locality. *L. aequalis* forma *nana*.

Leptasterias aequalis variety *concinna* Verrill, 1914, page 132. Monterey Bay, Calif. Type in Yale Museum; studied. Synonym of *L. aequalis* forma *aequalis*.

Leptasterias epichlora Verrill (not Brandt), 1914, page 132. Sitka. Verrill's *epichlora* covers part of *L. hexactis* and *L. alaskensis*. See below.

Leptasterias epichlora alaskensis Verrill, 1914, page 136. Dutch Harbor, Unalaska. (Pl. 85.) Type missing from Yale Museum, 1927. Name restricted to *L. alaskensis;* used by Verrill for *alaskensis*, *multispina*, and *hexactis*, part.

Leptasterias epichlora alaskensis variety *carinella* Verrill, 1914, page 137. Sitka and Dutch Harbor; Dutch Harbor herewith designated as type locality. No specimens in Yale Museum, 1927. Believed to be young of *L. alaskensis*.

Leptasterias epichlora alaskensis variety *siderea* Verrill, 1914, page 137. Several localities, Sitka to Dutch Harbor. Yakutat herewith designated as type locality. Type figured, but neither it nor any other example in Yale Museum, 1927. *Leptasterias hexactis* forma *siderea*.

Leptasterias epichlora miliaris Verrill, 1914, page 138. Cape Fox, Sitka, Alaska; Queen Charlotte Islands. No figure; no specimens in Yale Museum, 1927. A young form, said to resemble *L. aequalis;* possibly the young of *L. hexactis* forma *plena*.

Leptasterias epichlora miliaris variety *regularis* Verrill, 1914, page 139. Cape Fox, southern Alaska. Authentic specimen seen at Yale Museum. *L. hexactis* forma *regularis*.

Leptasterias epichlora miliaris variety *subregularis* Verrill, 1914, page 139. Sitka, Alaska. Not figured; no specimen in Yale Museum, 1927. Possibly the same as *regularis;* or a 6-rayed *Evasterias troschelii*.

Leptasterias epichlora miliaris variety *subnodulosa* Verrill, 1914, page 139. Wrangel, Alaska. No specimen in Yale Museum, 1927. This is almost certainly young *Evasterias troschelii*.

Leptasterias epichlora plena Verrill, 1914, page 140. Vancouver Island. Type in Victoria Memorial Museum, Ottawa; studied. *L. hexactis* forma *plena*.

Leptasterias epichlora pugetana Verrill, 1914, page 142. Puget Sound. Type from University of California. This is a variation of *L. hexactis* forma *regularis*.

Leptasterias (?) *dispar* Verrill, 1914, page 142. Dutch Harbor, Unalaska. Type in Yale Museum; studied. *Leptasterias camtschatica dispar*.

Stenasterias macropora Verrill (*Asterias macropora* 1909), 1914, page 145. Sitka; Queen Charlotte Islands. Stated, 1909, to be 5-rayed, and 1914, 6-rayed; R 15 mm. No specimens in Yale Museum, 1927. Probably does not belong in this section.

It is extremely unfortunate that Verrill resuscitated Brandt's *Asterias epichlora* for any 6-rayed sea star. Brandt distinctly says that his species is 5 rayed, and to assume that he had a 5-rayed variant of a normally 6-rayed species is to stretch probability too far. After examining literally hundreds of specimens of *L. alaskensis*, *L. camtschatica*, *L. hexactis*, and *L. aequalis* and their various formae, I have found exactly one 5-rayed *L. hexactis* forma *aspera* (Kodiak).

It is probable that Brandt had a young *Evasterias troschelii* forma *alveolata*. Verrill himself described small examples of this form as variety *subnodulosa* under *Leptasterias epichlora*. Many years ago Doctor Stimpson restricted *epichlora* to what I have called *Evasterias troschelii* f. *alveolata*. I think he was right. He knew that young *alveolata* is sometimes green.

All of the examples of Verrill's "*epichlora*" which I was able to find at the Yale Museum in 1921 and 1925 (Sitka, Wrangell, Cape Fox) are referable to *L. hexactis* forma *regularis* and *aspera*. One specimen of *L. alaskensis* labeled Sitka, is certainly not from there, but probably from west of Kodiak Island. The straight pedicellariae are unmistakable.

In view of all this uncertainty it is best to discard the name *epichlora*. If it were referable to a 6-rayed *Leptasterias*, the probabilities would be in favor of *L. hexactis* forma *regularis*.

LEPTASTERIAS CAMTSCHATICA (Brandt)

Plate 42, Figures 1, 1*a*–1*d*; Plate 49, Figure 1

Asterias camtschatica Brandt, Prodromus, 1835, p. 270 (Kamchatka).—Sladen, Challenger Asteroidea, 1889, p. 820.

Asteracanthium camtschaticum Brandt, in Middendorff's Reise, vol. 2, 1851, p. 32.

? *Asteracanthion camtschaticus* Grube, Nova Acta Acad. Caes. Leop. Carol. Nat. Cur., vol. 27, 1857, p. 23.

Asterias multiclava Verrill, Shallow-water Starfishes, 1914, p. 114, pl. 58, fig. 2; pl. 59, fig. 1; pl. 69, fig. 1; pl. 84, figs. 2, 2*a*.

Leptasterias camtschatica Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 12, 1923, p. 599.

Diagnosis.—Rays six, of medium width and length, tapered rather evenly. R 62 mm., r 14 mm., r=4.4 r; breadth of ray at base, about 15 mm. A small species differing from *L. alaskensis* Verrill in the presence of a nearly complete series of actinal plates and spines, together with a short second series at base of ray; in the more regular arrangement of the spines and papulae of the lateral parts of the abactinal area; in the size and form of the straight pedicellariae, which are small, compressed, and lanceolate or ovate, not large with broad obtuse denticulate jaws.

Description.—Abactinal spines short, fairly robust and of nearly uniform length (0.45 to 0.55 mm.), with denticulate capitate tips, the denticles arranged more or less in definite rows, or without serial arrangement. Spines typically in rather poorly defined longiseries, except for those bordering a conspicuous supramarginal channel which usually form a very regular longiseries. The carinal plates each carry several spines so that the midradial line is occupied by a series of small crowded groups of spines, somewhat larger than the others. Between these and the regular lateral series there is sometimes one zigzag series, or two, or the space may be filled with spines not regularly arranged. Those of disk form small groups, or stand singly, but are not typically acervate.

The papular areas are in more or less distinguishable longiseries abactinally. Those occupying the supramarginal channel form a fairly straight row. Two others between this series and the carinal plates can be made out in some specimens—six for the abactinal area (Petropavlovsk, Kuril Islands). In two specimens from Medni, Commander Islands, the central area of ray is broken up and irregular. One series of intermarginal areas; proximally two series and distally one of actinal. Areas small, two to five papulae each.

Superomarginal spines two, capitate, striate, sometimes a trifle larger than the dorsals, forming a regular duplicate longiseries rather high on side of ray, with the conspicuous supramarginal channel above and an intermarginal channel below. A specimen from Petropavlovsk has an arcuate vertical series of three spines on most of the plates. The marginal series of plates bend upward at the base of the ray, and the upper series of spines, which border the abactinal surface, passes inward on the interradial line, adjacent to the same series of the neighboring ray.

The inferomarginal spines are usually one to a plate proximally and two distally. They are cylindrical, or slightly clavate, round-tipped, and are distinctly heavier and longer than the superomarginals on the proximal half of the ray, but only a trifle larger distally, where the lower of the two spines is sometimes longer than the upper. In this case the upper is subequal to the superomarginals. There are two series of actinal spines (and two series of plates), the outer extending three-fourths to nearly the whole length of the ray, while the inner reaches to the middle in large specimens (R 47 mm.).

The first five to eight adambulacral plates carry a single, slender, rather long, terete slightly tapered blunt spine, followed by a very variable number (usually few) which have mostly two spines. Then the plates have one and two spines in fairly regular alternation; or less often mostly one spine with diplacanthid plates irregularly scattered. Beyond the first half dozen adoral plates the spines become shorter and thicker, often clavate, with the exception of the alternate furrow spine of diplacanthid plates, which is generally decidedly slenderer than the others. It is, however, frequently of the same clavate, or club-shaped, form as the others. The first three pairs of adoral adambulacral plates are in contact interradially; the first two plates are longer than the succeeding plates by about 30 to 50 per cent.

Mouth plates very similar to those of *alaskensis* and typically there are three spines, two at the inner apex and one at the actinal surface. Sometimes the shorter of the apical spines, which corresponds to the furrow spine of diplacanthid adambulacral plates, is lacking. The longer, that adjacent to median suture, is about as long as this suture, or a little shorter. The two spines of a pair are frequently dissimilar in length. The suboral is slender, tapering, and upwards of twice the length of the apical spine.

Straight pedicellariae (pl. 42 fig. 1*c*) inconspicuous and few abactinally, outside the supramarginal channels. They are broadly lanceolate to ovate, sharp to blunt, and measure 0.36–0.46 mm. They are very inconsiderable in size as compared to the spines and are so much smaller and different in form from the corresponding ones of *alaskensis* that they furnish a convenient character for identification. There is the usual cordon of small pedicellariae along the furrow face of the adambulacrals, as well as on the oral and first six or eight adambulacral spines.

Crossed pedicellariae (pl. 42 fig. 1*b*) are small, blunt, with a rather extensive terminal lip. They measure about 0.2 to 0.26 mm. in length abactinally, where they form a sparse series around the spinelets or occur only here and there on the integument between (Medni). They form wreaths on the superomarginals and clusters on the outer (upper) side of inferomarginals, actinal and adambulacral spines.

Madreporic body circular, rather small, situated about mid r, and surrounded by a circle of spines.

Color in life: "Above, deep olive green with the tips of the spines whitish; those of the edges very pink." (L. Stejneger, note on specimen from Bering Island).

Variations.—The specimens from the Commander Islands have somewhat less regularly arranged abactinal spines than have the Kamchatkan examples. The latter have somewhat broader, more evenly tapered rays, and on either side two pretty regular dorsolateral series of spines.

The three specimens from Simushir, Kuril Islands, are small (R 7, 21, and 25 mm.) yet the actinal plates and spines are well developed in the two larger. These and the small straight pedicellariae will serve to differentiate the species from *L. alaskensis asiatica*, with which it is associated. The abactinal papulae are in six longiseries, but the intervening spines are not regular. Many of the dorsolateral plates carry two or three spines, while in Petropavlovsk specimens there is more often only one spine, although plates with two or three do occur here and there. The superomarginal, inferomarginal, and actinal spines of the Simushir example are relatively longer and a little slenderer than in either Bering Island or Petropavlovsk specimens, and there is but one apical oral spine. Straight pedicellariae are fairly numerous, compressed, lanceolate ovate, obtuse to fairly acute.

Type locality.—Kamchatka.

Distribution.—Commander Islands, Kamtschatka, and the Kuril Islands.

Specimens examined.—Fourteen.

Bering Island, Commander Islands, L. Stejneger, 1883; one specimen. Nikolski, Bering Island, Commander Islands, shore rocks, June 15, 1906, *Albatross*, two specimens. Medni Island, Commander Islands, shore rocks, June 13, 1906, *Albatross*, three specimens. Petropavlovsk, Kamchatka, harbor, August 13, 1896, June 18, 1906, *Albatross*, five specimens. Milne Bay, Simushir, Kuril Islands, shore, June 23, 1906, *Albatross*, three specimens.

Remarks.—Brandt's diagnosis reads: "Disci diameter circiter pollicaris. Radii sex conici acuminati, longitudine vix subequales, pollicis unius vel 1¼ longitudine, anti basin multo latiores. Totum dorsum umbrinum vel ochraceum papillisque pedicellatis, truncato-capitatis, frequentibus, albis vel e fuscente albidis, eminentiis reticulatis impositis, in radiis series subregulares formantibus obsessum. In mari Camtschatico." On page 32 of the Reise, he says: "Unterscheidet sich durch das Vorkommen von 6 armen * * * und auf dem Rücken 6 bis 7 Reihen geköpfter Stacheln tragen, so wie durch dreireihige dünne Ambulacral stacheln."

It is apparent that Brandt was describing a small Kamchatkan sea star with six tapered pointed rays in which the small, numerous, truncate capitate spines were arranged in six or seven sub-regular longiseries. This diagnosis agrees with the species under discussion. On some specimens the adambulacral spines appear as if three ranked owing to the posture of the spines. The furrow spine of diplacanthid plates is directed obliquely over furrow, the other obliquely toward the actinal spines. These form the inner and outer series, while the middle series is formed by the upright spine of the alternate monacanthid plates.

Verrill in commenting upon Brandt's description, which he considers indefinite and vague, renders "*series subregulares*," "subangular series." This error obscures Brandt's meaning. It seems to me that the description is definite enough. Moreover there is no Kamchatkan species, other than the one under discussion, which has six rays and the abactinal spinelets in somewhat regular longiseries. From Brandt's comments in Middendorff's Reise (1851, p. 32) he apparently had specimens which had been dried without much prior preservation. Grube in fact says (1857, p. 24) that his description seemed to have been made from only dry material.

LEPTASTERIAS CAMTSCHATICA DISPAR (Verrill)

Plate 42, Figures 2, 3, 4; Plate 49, Figures 2–6; Plate 50, Figure 1

Leptasterias (?) *dispar* Verrill, Shallow-water Starfishes, 1914, p. 142, pl. 16, fig. 7, type; pl. 106, fig. 3 (as *acervata*).

This polymorphic race is the representative of *Leptasterias camtschatica* on the Aleutian chain, whence it extends as far as Kodiak Island. It is found in Bering Sea at the Pribilof Islands. The name of the race is derived from one of its formae, originally described as a distinct species.

Three phases or formae have been distinguished—*nitida*, *nesiotis*, and *dispar*, of which the first is the equivalent of the common form of *L. camtschatica camtschatica*. In the Asiatic race only one form has been observed.

These three phases are morphologically equivalent to formae found in widely dissimilar species. For example they correspond, in the order named, to *Pisaster ochraceus* f. *ochraceus*, f. *confertas*, f. *nodiferus;* or to *Evasterias troschelii* f. *alveolata*, f. *acanthostoma*, f. *troschelii*.

The small type variety of f. *dispar* does not resemble f. *nitida* (which is the equivalent of *L. camtschatica camtschatica*). Therefore only forma *nitida* is useful for direct comparison with true *camtschatica*, since no equivalent of *dispar* is known for the latter species.

However distinct *dispar* may appear to be when only extreme forms are compared, there exists a pretty complete series of intermediate specimens connecting it with f. *nitida*. There is available the alternative of regarding *dispar* as a distinct species which has freely crossed with *nitida*. *Dispar* has been taken on the outer part of the Aleutian chain where *nitida* has not yet been found (but where it may nevertheless occur). There seems to be no necessity of invoking hybridism, for quite as dissimilar formae are known in other species of the genus, for example, *Leptasterias polaris acervata*.

If these formae breed fairly true when isolated I presume it is simply a question of terminology whether they be called formae or species. The fact remains, however, that *intermediate* specimens occur at localities where only extreme examples of *dispar* (but not *nitida*) have been found (Attu), and also where neither *nitida* nor extreme *dispar* have been collected (Atka and Shumagin Islands).

In the following description the formae have been listed in the order of their resemblance to *L. camtschatica*. It is a taxonomic episode that the race must have a name which connotes a form morphologically so dissimilar to *camtschatica*.

Forma NITIDA, new forma

Plate 42, Figures 3, 3*a*–3*c*; Plate 49, Figure 2; Plate 50, Figure 1

This corresponds to the typical form of *camtschatica*. The abactinal spinelets are much more numerous and do not form evident longiseries with the exception of the carinals which are larger than the dorsolaterals, more crowded, and occur in groups, close together, so that a carinal band of more crowded spinelets can be differentiated. The marginal plates are rather high on side of ray. Just above them is a typically narrow, regular channel—the supramarginal—containing a straight series of papulae. Between this channel and the edge of the carinal band (4 or 5 mm. in fully grown specimens) the spinelets are thickly scattered, with a tendency to form short transverse lines, especially adjacent to the superomarginals. A few of these lines extend entirely across the dorsolateral area and seem in some cases to be continued by the superomarginal combs.

Superomarginal spines three to five, usually arranged in an arcuate vertical series of three or four proximally and three or two distally, with occasionally another smaller spine on the adoral lobe of the plate. The spines are capitate slightly larger or subequal to the dorsals, and form a regular series of combs rather high on the side of the ray.

Intermarginal channel narrow. Inferomarginal spines two (usually one on first four or five plates), much more robust and about twice as long as the superomarginals. The end is usually swollen and turned upward slightly. Two series of actinal plates, one reaching 0.8 the length of R, the inner about 0.5 R in fully grown specimens. Spines, one to a plate, similar to the inferomarginal spines. The inner series of actinals sometimes extends only a slight distance upon the ray.

Adambulacral spines similar to those of *camtschatica*. The first four to eight plates have one spine; then a few may have two, followed by two and one in not very regular alternation; then on outer part of ray the plates are monacanthid by the suppression of the outer spine of diplacanthid plates. This results in alternate plates having only a furrow spine, which is slender and more advanced into the furrow than the clavate, subtruncate subambulacral spine of the intervening, original monacanthid plates. Three pairs of adoral adambulacral plates, as in *camtschatica*, are in contact interradially back of oral plates.

Mouth plates similar to those of *camtschatica*. In this forma the outer or smaller of the two actinostomial or apical spines is missing.

Papular areas small, with few papulae. The abactinal do not form regular longiseries except adjacent to superomarginal plates.

Very small lanceolate pedicellariae are found on the abactinal surface. Ovate to lanceolate acute, larger ones, as large as 0.8 mm. long, are found rather plentifully in the marginal and actinal channels, on the proximal adambulacral spines, oral spines, and along the furrow face of the adambulacrals.

Crossed pedicellariae, variable in numbers, are distributed as in *camtschatica.* They are frequently abundant inferomarginally and actinally. The abactinal measure 0.24 to 0.27 mm.

Madreporic plate inconspicuous, partly overhung by the numerous encircling spinelets.

Anatomical notes.—There is nothing peculiar or unusual about the skeleton of this form. The carinal plates are conspicuous when denuded and are imbricated directly to form an irregular series. They appear to have been originally four lobed; in adult specimens the contour is irregular. The marginal and actinal plates have a warped 4-lobed contour, the upper or outer lobe being more advanced toward end of ray (transverse axis of plate, oblique). The outer row or actinals nearly reaches the end of ray while the inner attains about the middle, measured on side. The dorsolaterals, smaller than either marginals or carinals, are irregular in contour and without regularity in arrangement. The intervals of the skeleton are smaller than plates on basal half of ray; slightly larger on distal half.

Variations.—The dorsolateral spinelets become a little more widely spaced while the carinal are aggregated into slight convex differentiated groups. These groups are not as prominent as in typical *dispar*. *L. dispar* may be achieved by the reduction in the number of the dorsolateral and superomarginal spinelets. These incipiently "acervate" examples are found at Kodiak Island (Karluk) (pl. 50, fig. 1), Unalaska, Pribilof Islands (St. Paul and St. George). A number of specimens from St. George (pl. 49, fig. 4) exhibit this variation in a marked degree and I have noted them under *dispar* although they are really perhaps as close to *nitida.* The spines of the convex carinal groups are closely aggregated. At the base of the ray there are sometimes one or two adradial clusters. Superomarginals, two or three.

As mentioned above this incipiently clustered condition of the carinal spinelets is shown by a few specimens from Karluk, Kodiak, which resemble and may perhaps be intermediate with *L. hexactis* f. *siderea,* which occurs with them, at low tide.

Type of forma nitida.—Cat. No. E1493, U.S.N.M.

Type locality.—St. Paul, Pribilof Islands, Bering Sea, rocks at low tide. Collected by William Palmer.

Distribution.—Pribilof Islands, Unalaska, and Kodiak (Karluk).

Forma NESIOTIS, new forma

Plate 42, Figures 2, 2*a*; Plate 49, Figure 3

This differs from forma *nitida* in having much more delicate spinelets. Typically the carinal spinelets are not any larger or only slightly larger than the other abactinal spinelets and the mouth plates generally have two spines each at the actinostomial end.

The abactinal skeleton is sometimes more open than in *nitida,* the papular areas forming longiseries of which one above the superomarginal plates and one on either side of the carinals is evident, while one between these two is likely to be broken up.

Potentially there are six longiseries on the abactinal area. In some variations the spinelets are so arranged that a reticulate or areolated pattern is formed. Such specimens may be readily distinguished from forms of *L. alaskensis* by the presence of a long series of actinal spines and by the small lanceolate straight pedicellariae of the sides of ray.

The number of superomarginal spines is usually three or four in an arcuate vertical series. Owing to their smaller size they appear to be more spaced than in *nitida*. The inferomarginal and actinal spines are much slenderer than in *nitida* but number the same.

The lanceolate straight pedicellariae are appreciably smaller than those of *nitida*, measuring 0.3 to 0.45 mm. (Pl. 49, fig. 2*a*.) The abactinal crossed pedicellariae measure 0.16 to 0.21 mm.

This form predominates at St. Paul, Pribilof Islands, where it far outnumbers *nitida* judging by the series collected by Dr. G. D. Hanna. The type was taken at Village Point, July 25, 1920, among bowlders, between tides, along with *L. alaskensis*. This forma has not been found elsewhere.

Color in life.—Dr. G. Dallas Hanna collected at St. Paul, Pribilof Islands, 20 specimens of forma *nesiotis* and intergrades and made notes of the color variations. The following notes refer to 11 specimens taken from an area 3 feet square, among bowlders, near the village:

1. Dorsal surface olive spotted with dark brown; ventral surface light pink.

a. Lighter olive, with more reddish spots.

b. Spots very dark brown, almost black, the interspaces yellow.

c. Dorsal spots black, interspaces pure yellow.

d. Under side with yellowish tinge on the pink.

2. Dorsal surface clearer green, the spots very dark brown; ventral surface, darker pink.

The following specimens were taken July 25, 1920, at Village Point, between tides:

1. Upper surface with large black blotch or blotches on disk of very irregular form, but in every case filling center of disk and radiating upon each arm forming thus a stellate area; remainder yellow, pink on either side of the groove.

a. Blotches very dark blood red, remainder a dirty gray; margins of furrow, light pink.

b. Blotches dark lavender, remainder gray; margins of furrow, light pink. (Type of forma *nesiotis*.)

Type of forma nesiotis.—Cat. No. E 1494, U.S.N.M.

Type locality.—St. Paul, Pribilof Islands, Bering Sea, August, 1920, collected by G. Dallas Hanna.

Forma DISPAR Verrill

Plate 42, Figure 4, 4*a*, 4*b*; Plate 49, Figures 4, 5, 6

Leptasterias ? dispar VERRILL, 1914, pl. 16, fig. 7; pl. 106, fig. 3 (as *Asterias acervata*).

A 6-rayed form differing from forma *nitida* in having the carinal spines much enlarged and usually grouped in nodular clusters; typically few dorsolateral spines much smaller than the carinals; a conspicuous supramarginal channel, bounded above in large specimens by a very regular series of small dorsolateral spines and below by one or two series of robust superomarginal spines. R 66 mm., r 17 mm. R=3.88 r; breadth of ray at base 18 to 20 mm. (Attu Island).

Verrill's type and only listed specimen of this variable form is a small example from Unalaska. Under the caption of *Asterias acervata* he gives a good figure (pl. 106, fig. 3) of a variety from Nazan Bay, Atka. I have two specimens of the same lot, collected by W. H. Dall, 1873.

The type is an extreme variant of the form and is farthest removed in appearance from *nitida*. I have three small examples of this subforma from Unalaska (type locality, pl. 49, fig. 6), two small and one large specimen from Attu (pl. 49, fig. 5) at the end of the Aleutian chain. Of the intermediate stages between this extreme and acervate examples of *nitida* there is a pretty complete series. Scarcely two specimens are alike.

The large example from Attu (R 66 mm.) has the carinal line armed with very prominent clusters of large capitate spines, three to five in a group, forming a zigzag longiseries; 10 or 11 similar groups mark the primary plates of disk. These spines are larger than any of the others, stand well above the general level, and have convex, finely striated tops, upward of 1.75 mm. in diameter. On the inner side of the broad supramarginal channel which is abactinal in position is a line of relatively small capitate spines, fairly well spaced and not reaching end of ray. Scattered between these and the carinal groups are a *relatively few* similar spines which sometimes form a poorly defined series for a short distance. The spinulation between the superomarginal and carinal series is characteristically meager, but this feature is very variable in different specimens from the same locality. In the extreme as represented by the small type there may be only a single very interrupted series of small dorsolateral spinelets, and a single irregular series of spaced subtruncate carinal tubercles.

The superomarginal spines are either one or two to a plate, usually one in the small type form, but two in large specimens, where they stand close together on the plate and form a prominent duplicate series defining the dorsolateral margin of the ray, which is more definite and prominent than in *nitida*. Spines cylindrical, slightly capitate, striate and subtruncate, about 1.25 mm. long, and a little bigger than the dorsolateral spines. The intermarginal channel, though variable, is broad proximally in both large and small examples.

Inferomarginal spines usually one on the first three to six plates, then two, with an occasional monacanthid plate; less often a plate carries three spines. A series of similar actinal spines reaches about 0.8 R along ray, while a very short second series is also present. These spines are cylindrical, round-tipped, and longer and thicker than the superomarginals (about 2.5 mm.). In typical small specimens the spines are more prominent and likely to be compressed; they form a bristling ventrolateral border, and the actinal series is short.

The first four to six adambulacral plates are monacanthid; then follow about 20 diplacanthid plates; then a variable number alternate with one and two spines. About the last fourth or fifth of the ray has monacanthid plates (a plate bearing a furrow spine alternating with one carrying a subambulacral). The spines are similar in form to those of *nitida*. Toward the mouth plates they gradually lengthen and become slenderer. In the median part of the ray the subambulacral spines are cylindrical, or slightly clavate, round-tipped. The furrow spines are slenderer and tapered. There are three pairs of contiguous plates back of the mouth plates.

Mouth plates very similar to those of *camtschatica*. There are two actinostomial spines and one suboral. The smaller of the two apical spines is bent across the beginning of the radial nerve. The other, about twice as long (2 mm.), is a trifle longer than the median oral suture.

The series of actinal, intermarginal, and supramarginal papular areas are regular, but the other dorsolateral areas are not at all regularly arranged. They vary greatly in number according to the age of the specimen and appear not to be of diagnostic value. There are only a few papulae to each group. In small examples they are mostly single.

Straight pedicellariae are all small and are of the lanceolate and ovate compressed type, quite inconsiderable in bulk as compared to the spines. The dorsal are commonest interradially and along the supramarginal channel, and are lanceolate-ovate, or ovate, blunt, or subacute; the intermarginal and actinal are similar but a little larger. They occur in clusters on the oral spines and among the crossed pedicellariae of the furrow spines.

Crossed pedicellariae, distributed as in *nitida*, are fairly numerous in large specimens, but few, especially on the abactinal surface, in small ones. Their size varies with that of the specimen. On large examples they measure 0.25 to 0.27 mm. (Pl. 42, figs. 4*a*, 4*b*.)

Madreporic body circular, situated at about the middle of r, surrounded by a complete or an incomplete ring of short capitate spines. Striae rather coarse, radiating from center.

In small specimens, as Verrill states, the ambulacral groove is broad. This feature may be masked by the arching of the abactinal surface, so that the edges of the furrow are drawn together.

Anatomical notes.—In small specimens the carinal and superomarginal plates are disproportionately large as compared to the irregular dorsolaterals. The triserial arrangement of the dorsal plates, mentioned by Verrill, is lost in large examples by the interpolation of plates between the carinals and the primary dorsolateral series (that which borders the supramarginal channel). In typical large examples such as that from Attu, the carinals are, nevertheless, still relatively large. (Pl. 49, fig. 5.)

The gonads open ventrally. The apertures are close to the interradial line, and in line with the outer actinal row of papulae. Each is at the summit of a low prominent papilla, and the specimen (R 57 mm.) taken at Attu, June 10–11, 1906, has large but subspherical, nodular ovaries filled with ripe eggs. Another large specimen, that described, taken May 29, 1892, at Attu, is a male and the gonads are of the branched type common to the males of this genus. The gonads appear to be not fully mature. A mature female, taken June 15, 1920, at Unalaska, has R only 26 mm.

Variations.—The small typical subforma as described by Verrill is unmistakable, but this is an extreme having a minimum of abactinal spines and usually one series of prominent superomarginal spines. The carinals are few and unusually large, as if there were only a certain amount of lime to be expended—the larger the spines the fewer their number. In larger specimens the number of carinal spines varies from one to a plate to a crowded group of five or six, and the size, from slightly to conspicuously larger than the dorsolaterals. The dorsolateral spinelets vary from one incomplete longiseries to the equivalent of three, such specimens being in fact nothing more than examples of *nitida* with grouped carinal and spaced dorsolateral spinelets.

Shumagin Islands: Largest specimen, R 47 mm., has one or two superomarginal spines, rather numerous dorsolaterals, and not very prominent acervate carinals. The five specimens from the Shumagins suggest young *acervata*, but are not.

Chernoffski Bay, Unalaska: A specimen (47 R mm.) has rather narrow, arched rays and proximally three or four superomarginal spines, in an arcuate vertical comb.

Unalaska, Alaska: In addition to three small typical examples there are nine intermediates some of which may be called acervate examples of *nitida*. The spines of the conical groups are not neat and compact as in the St. George Island variety. Superomarginal spines usually two, sometimes one.

St. George Island, Pribilof Islands: These belong really to a subforma of *nitida* rather than to forma *dispar*. Along the carinal ridge (the ray being well arched) is a zigzag series of conspicuous, convex, compact groups of 8 to 12 unequal, but enlarged, close-set spines; dorsolateral spines numerous, superomarginals two or three. (See under f. *nitida*, pl. 49, fig. 4.)

Adakh Island, Andreanof Group, Aleutian Islands: A specimen resembles the St. George examples but the groups are smaller; the superomarginals two; R 73 mm. There are rather numerous coarse ovate intermarginal straight pedicellariae but they are not of the form nor nearly as large as those of *alaskensis*. This large specimen may be classified as an acervate specimen of forma *nitida*, or as *dispar* with numerous dorsolateral spinelets. One specimen with much fewer dorsolateral spinelets.

Nazan Bay, Atka: The specimen figured by Verrill (1914, pl. 106, fig. 3) is much smaller than the two recorded here (R 70 and R 65 mm.). In these the carinal spines are prominent and the dorsolaterals well spaced but more numerous than in the example from Attu described above. Superomarginals two. Intermarginal straight pedicellariae smaller than in the Adakh example.

Attu Island: A small example with two superomarginal spines connects the extreme type form, from Chickagoff Harbor, Attu, with what might be called the intermediate variety, of which there is one specimen (in addition to the large extreme form described) collected at the same locality.

Remarks.—The following differences may be observed between approximately equal-sized specimens of f. *dispar* and *Leptasterias polaris acervata* f. *acervata;* examples of *acervata* with R 50 to 70 mm.; of *dispar* with R 66 mm. *Acervata* has a smaller disk, and the rays are slenderer, especially at the base (R = 4.5 to 5 r). The dorsolateral spines are much more numerous, and a certain number of them are enlarged (as are the carinals) and form spaced, scattered clumps which are strongly convex. The supramarginal and intermarginal channels are narrow, the former being not at all conspicuous, as in *dispar*. In typical *dispar* the superomarginal plates are more prominent, the spines being a little longer. Small specimens of *acervata* (R 22 to 27 mm.) do not resemble equal-sized typical *dispar* but they do resemble some of the intermediate stages of *dispar* from Unalaska. The latter lack the dorsolateral convex groups of acervate spines.

Type of forma dispar.—In Yale Museum.

Type locality.—Dutch Harbor, Unalaska (forma *dispar*).

Distribution of forma dispar.—Attu Island to the Shumagin Islands and southern Bering Sea (Pribilof Islands). The subspecies *dispar* extends from Kodiak Island (forma *nitida*) to Attu (forma *dispar*).

Specimens examined.—Eighty.

Specimens of Leptasterias camtschatica dispar examined

Locality	f. *nitida*	f. *nesiotis*	f. *dispar*	Remarks
Unalaska (Chernofski Bay)			1	U.S.N.M.
Unalaska	4		12	3 typical *dispar;* intermediates; U.S.N.M.; Stanford.
Round Island, Coal Harbor, Unga, Shumagin Islands.			4	U.S.N.M.; W. H. Dall; intermediates.
Popoff Strait, Shumagin Islands			1	Do.
St. Paul, Pribilof Islands	8	20	2	U.S.N.M.; Stanford; G. D. Hanna, H. Heath.
St. George, Pribilof Islands	2		4	Stanford; H. Heath.
Adakh Island, Aleutians			2	U.S.N.M.; 1 intermediate.
Atka Island, Aleutians (Nazan Bay)			2	U.S.N.M.
Attu Island (Chichagoff Harbor)			5	U.S.N.M.; W. H. Dall 1873; Albatross, June 10, 1906.

LEPTASTERIAS ALEUTICA, new species

Plate 43, Figures 1, 1*a*–1*c*; Plate 50, Figures 2, 3

Diagnosis.—Rays six. Differing from *L. camtschatica dispar* in having shorter, thicker rays; more numerous, closer set abactinal spinelets, which have the appearance of a rather even, close, granuliform covering; relatively larger superomarginal plates, which with their groups and combs of four to six spines form a broader band along the dorsolateral border of ray. Straight pedicellariae small, ovate or ovate-lanceolate, acute or obtuse. Resembles a small *L. aequalis* without longiserial arrangement of the abactinal plates. R 28 mm., r 10 mm., R=2.8 r; breadth of ray at base 10 mm.

Description.—Rays short, robust. Abactinal surface arched, covered with many small, close-set, uniform spinelets, which give the whole abactinal area the appearance of being covered with granules. In small examples separate plates not easily distinguishable; in largest specimens, such as type, the small papular areas serve to mark off groups of spinelets. In the type, the largest plates (the carinals) carry 8 to 15 spinelets, the dorsolaterals 5 or 6. The spinelets are characteristically thorny 0.3 to 0.4 mm. long on abactinal plates. The irregular carinals sometimes have considerably more robust spinelets than dorsolaterals. Dorsolateral skeleton an irregular reticulum with the eqiuvalent of about six longiseries of papular areas for the whole abactinal area, only those adjacent to superomarginals at all regular.

Superomarginal plates with four to six spinelets (usually three or four in small specimens) which distally form a vertical comb and proximally more often a group. Exceptionally there are as many as eight to a group. The spinelets are a little longer than the abactinals, rather stubby and subclavate, sometimes curved. They form a conspicuous band well up on the side of the ray, and are bounded below by a narrow but fairly conspicuous intermarginal channel.

The inferomarginal spinelets stand two (sporadically three) to a plate. They are subcylindrical and are both longer and stouter than the superomarginals. The proximal spinelets may be nearly twice as long and 75 per cent thicker than superomarginals, and rather clavate in form. A series of actinal spinelets, similar to the inferomarginals but slightly larger, extends for two-thirds the length of the ray. A few spinelets of a second series may be present at the base of the ray. The inferomarginal and actinal spinelets together form three ventrolateral series separated from the broad band of superomarginal spinelets by the intermarginal channel.

Adambulacral plates diplacanthid for half or two-thirds the length of the furrow; the distals alternating diplacanthid and monacanthid; or the distal plates may be irregularly diplacanthid. The furrow spinelet is, as usual, slenderer than the adambulacral, which is subcylindrical and subclavate, about as long as the actinal spinelets but considerably slenderer. Both become longer and decidedly slenderer on the first dozen plates. The first five or six plates are monacanthid, and the first three pairs are contiguous interradially.

The oral plates have the usual arrangement of spinelets: Either one or two at the actinostomial end, and one suboral. The longer of the slender apical spinelets is as long as or a little longer than the median suture of the plates, and longer than in *alaskensis*.

Straight pedicellariae: There are a few small ovate or ovate-lanceolate, compressed, bluntly pointed to obtuse pedicellariae in the supramarginal, intermarginal, and actinal channels, and along the furrow face of the adambulacral plates, the latter being quite small. They occur in clusters on the oral armature and mixed with crossed pedicellariae on the furrow armature of the proximal half of the ray. The lateral and actinal dermal pedicellariae are much slenderer than any of the spines. The largest intermarginal measure 0.3 mm. (Pl. 43, figs, 1*b*, 1*c*.)

Abactinal crossed pedicellariae few and scattered, in circles around the spines. They form rings or part rings on the superomarginal spinelets, and not very large clusters on the outer side of the inferomarginal actinal, and adambulacral spines. Abactinal pedicellariae measure 0.18 to 0.2 mm. (Pl. 43, figs. 1*a*, 1*a′*.)

Madreporic body circular, surrounded by one or two cycles of granuliform spinelets and situated at about the middle of r, or a trifle nearer the center of disk.

Variations.—This species is typically small with short, rather stout, rays and a close, uniform covering of granuliform spinelets. It is sexually mature at R 14 mm., and the majority of the specimens have R less than 20 mm. The spine-counts in these small examples are less than in the largest specimens, but the spines are more uniform in size and distribution. Even in very small examples the actinal plates extend for half the length of the ray.

The superomarginal spinelets in small specimens form an arcuate vertical series of three or four with an extra spine on the adoral, convex side of the arc. This is essentially the arrangement in large specimens where extra spines appear on the adoral side of the arc of usually five spinelets.

Specimens from Unalaska, and a part of those from Adakh and Kyska are not typical and approach, sometimes closely, what appear to be young *L. camtschatica* *dispar* f. *nitida*. The difference briefly consists of a slight enlargement of the carinal spinelets and a disparity in the size of the dorsolateral spinelets, whereas in the typical form the abactinal spinelets are all fairly uniform. The really problematical specimens are small. It must be remembered that all young *Leptasterias* are peculiarly difficult. Forms which are easily separable in the adult phase may converge in the young stages so that exact differentiation is impossible.

Type.—Cat. No. E 1495, U.S.N.M.

Type locality.—Adakh Island, Aleutian Islands, July 2, 1893.

Specimens examined.—Forty-two from the following of the Aleutian Islands: Agattu, 2 specimens; Amchitka, 2 specimens; Kyska (Kyska Harbor), 6 specimens (W. H. Dall, 1873); Adakh, 8 specimens; Atka, 20 specimens; Unalaska, 4 specimens (variety).

Remarks.—This species, which so far as known is confined to the Aleutian Islands, reminds one of a small *L. aequalis* having irregular abactinal plates. It is probably an offshoot of *L. camtschatica*. Some of the smallest specimens approach *L. camtschatica dispar* f. *nitida*. *L. aleutica* has typically shorter, broader rays and more numerous and close-set dorsolateral spinelets, which are arranged in groups without serial alignment.

The resemblance to *aequalis* is perhaps due to the relationship which both species bear to *camtschatica*. Some variants of *L. hexactes vancouveri* closely resemble *L. camtschatica*.

L. aleutica can be distinguished from the forms of *L. alaskensis* by the small, compressed, ovate or ovate-lanceolate straight pedicellariae, numerous abactinal and superomarginal spinelets, and long series of actinal spinelets.

LEPTASTERIAS ASTEIRA, new species

Plate 43, Figures 3, 3*a*–3*e*; Plate 50, Figures 4, 5

Diagnosis.—Rays six, rather short and robust; abactinal spinelets subcapitate, generally one to a plate and pretty uniformly spaced, and not obviously areolated; carinal series not distinguishable from the rest; abactinal papulae one to three, not at all in series; superomarginal spines two; inferomarginal and actinal forming each a single series, well separated; adambulacral spinelets, two, and one and two alternating; ambulacral furrow narrow; straight pedicellariae small, ovate or elliptical, obtuse. R 26 mm., r 8.5 mm., R = 3 r; breadth of ray at base 9 mm.

Description.—Abactinal spinelets short, robust, clavate to subcapitate, the length being once or twice the breadth at tip, which is grooved and thorny. The spinelets are not very dissimilar in size, are mostly one to a plate, and are spaced one-half to two or three times their breadth but have the appearance of being pretty evenly scattered, without the slightest differentiation of a carinal series, a reticulated pattern of the abactinal spinelets only vaguely indicated in the larger specimens.

There is a fairly broad but variable and not very sharply differentiated supra marginal channel. Superomarginal spinelets two, sporadically three, slightly larger than the dorsals, fairly high on the side of ray. Intermarginal channel about as broad as the supramarginal. Inferomarginal spinelets generally one, occasionally two distally; actinals one, the series extending two-thirds or three-fourths the length of the ray; both are about 50 per cent larger than the superomarginals, subcylindrical to slightly clavate, and sometimes a trifle curved upward. The actinal channel is a little narrower than the intermarginal.

The first five or six adambulacral plates are monacanthid; then about five or six are diplacanthid; the remainder alternate more or less regularly with one and two spinelets. The subambulacral spinelets are clavate, a little slenderer than the actinals but often no shorter; the furrow spines are a little slenderer than the subambulacrals but instead of tapering, as is usual with furrow spinelets, are more often a trifle clavate. One or two pairs of adambulacral plates meet interradially behind the mouth plates.

Oral spinelets two; a tapering spine at the inner apex of each plate, shorter than the interradial suture; one suboral spinelet similar to the first few subambulacrals which are slenderer than further along the ray.

Abactinal papulae mostly single and inconspicuous; intermarginal and actinal (sometimes two series proximally) in twos and threes.

Straight pedicellariae (pl. 43, figs. 3*a*–3*c*) small, in side view ovate, or broadly elliptical, very obtuse, distributed typically for the genus, the largest being the actinal interradial dermal. Front profile of jaw, usually ovate or broadly lanceolate. The dorsal are very small, as are those along the furrow margin. An intermarginal measures 0.27 to 0.33 mm.; an actinal interradial about 0.3 mm.

The sheaths surrounding the abactinal spinelets are rather pulpy and prominent, often contiguous, but the crossed pedicellariae (0.2 mm.) are few, usually only one to three to each spine. The marginal are more numerous but not abundant; the inferomarginal, actinal, and the adambulacral form very small clusters. (Pl. 43, fig. 3*d*.)

Madreporic body small, situated one-half r from center.

Anatomical notes.—The hepatic coeca are large and reach nearly to the end of the ray. The intestinal coecum is a rather slender, 2-lobed sac. The gonads open ventrally by a genital papilla close to the interradial line. The ovaries are subglobular, the eggs large and relatively few (specimen with R 21 mm.).

The abactinal skeleton consists of an irregular small-meshed reticulum of very numerous small plates without a differentiated series of carinals. At the nodes are mostly three or four lobed primary plates (usually monacanthid) connected by one intermediate, elliptical, often monacanthid, ossicle. The spaces are larger and the plates slenderer toward the end of the ray. The superomarginal plates are four lobed, but at the base of the ray the transverse lobes only may be present on many inferomarginal plates, since the intermarginal and actinal papular areas are very frequently confluent. A second series of small actinal plates (more numerous than the outer series) is irregularly developed at the base of ray, but generally is not spiniferous.

Type.—Cat. No. E 1496, U.S.N.M.

Type locality.—Adakh Island, Andreanof Group, Aleutian Islands.

Distribution.—Pribilof Islands, Shumagin Islands, Andreanof Islands.

Specimens examined.—Pribilof Islands (St. George and St. Paul), shore, 4 specimens. Adakh Island, Aleutian Islands, shore, 32 specimens. Kyska Island, Rat Islands, Aleutians, 9–14 fathoms, 4 small specimens. Sanborn Harbor, Nagai, Shumagin Islands, 1 specimen. Round Island, Coal Harbor, Unga, Shumagin Islands, 1 specimen.

Remarks.—This species may be distinguished from *alaskensis* by the form of the small straight pedicellariae, by the absence of prominent groups of carinal and dorsolateral spinelets, by the generally more uniformly distributed dorsal spinelets which are of a pretty uniform size, by the narrower abactinal area and higher position of superomarginals on the side of the ray, and by the well developed series of actinal plates. It differs from *camtschatica* in lacking any trace of serial arrangement of the abactinal spinelets and in the absence of any crowding or differentiation of the carinal spinelets, the same distinction separating it from *dispar*. It further differs in having shorter rays, the intermarginal and actinal papular areas confluent, and very obtuse-ovate or elliptic, small straight pedicellariae.

Asteira is probably one of the *camtschatica* group of species, as evidenced by the well developed actinal plates. It appears to be distinct from all the forms of *camtschatica* and *hexactis*. The pedicellariae are rather distinctive.

LEPTASTERIAS LEPTODOMA, new species

Plate 43, Figures 2, 2*a*, 2*b*; Plate 50, Figure 6

Diagnosis.—Rays six. Skeleton weak; abactinal spinelets small, rather widely scattered; carinals not clearly differentiated; superomarginal, inferomarginal, and actinal spines typically one to a plate, forming three definite lateral series well spaced from one another; adambulacral plates monacanthid; apical oral spines rather long; lanceolate dermal straight pedicellariae; integument rather thick pulpy, and thrown into irregular transverse folds; abactinal integument rather flaccid. Rays slender, well arched. R 29 mm., r 7 mm., R = 4 + r; breadth of ray at base, 7 mm.

Description.—Abactinal skeleton weak, entirely obscured in alcoholic specimens by pulpy integument which is raised in low, irregular, transverse folds and circular disks surrounding the widely spaced small spinelets. These cushions seldom carry pedicellariae abactinally. Abactinal skeleton very irregular, the plates thin, small, irregularly elliptical, oblong, three or four lobed; skeletal intervals small to large; usually a series of large intervals directly above superomarginal plates. Lobed plates usually carry a single short, tapered, subtruncate spinelet (two or three on a few plates of disk). These are spaced 3 to 10 spine lengths apart and sometimes form three very irregular longiseries, or else are without serial order. They vary greatly in number but for the genus are few and widely spaced.

Superomarginal spinelets, a little longer than abactinals, one to a plate, surrounded by a pulpy disk bearing one to several crossed pedicellariae. They form a very regular series rather high up on the side of the ray.

Similarly there is a single series of inferomarginal, and one of actinal spinelets (extending two-thirds to three-fourths the length of the ray). In the largest specimens there is a second short series of actinals. The spinelets are slender, terete, blunt, and increase in length toward the furrow, the actinals being longest (upward of 1.5 mm.) and sometimes curved. The intermarginal and actinal channels (both lateral in position) are broad, so that the three lateral series of spines are well separated and the actinals are also fairly well spaced from the adambulacrals. The intermarginal and actinal papular areas are frequently confluent, forming very large subquadrangular spaces reaching from the superomarginal to the actinal plates. It may happen that a whole series of inferomarginal plates is thus disconnected.

On either side of ray there are three fairly regular series of papulae—an actinal, an intermarginal, and a supramarginal, with one to four in each cluster. The abactinal, one to three in each area, are very irregularly distributed and the areas are variable in number. Usually the papulae are few.

Adambulacral plates monacanthid. The spinelets are very slender, terete, blunt, a little shorter and considerably slenderer than the actinals. The spinelet of alternate plates is situated on the furrow margin while the other is spaced back from margin. In the type there is very little difference in size between the two; but in the largest specimen from Unalaska, the outer is longer, heavier, and slightly compressed at the truncate tip. The inner tapers a little, as is usual with furrow spines. First pair of adambulacrals contiguous interradially, conspicuously longer than second pair.

In the type, 5 of the 10 oral plates carry 2 suboral spines, one carries 3, the rest 1. Other specimens generally carry one. There are two apical spines, both tapered, slender, the inner a little longer than the plate, the outer (adjacent to furrow) nearly as long. Both are longer than in *alaskensis*.

Straight pedicellariae (pl. 43, fig. 2), slender to broadly lanceolate, are scattered over lateral abactinal regions; others occur in the intermarginal and actinal channels, in clusters on the oral spines, and sparingly on the furrow spines. Very small ones are scattered along the furrow face of the adambulacral plates. Intermarginal pedicellariae measure about 0.5 mm. long.

Crossed pedicellariae, very scarce abactinally. A few form rings around the superomarginal spines (sometimes absent), and small clusters on the inferomarginal, actinal, and adambulacral spines. The abactinal and superomarginal (pl. 43, fig. 2*a*) measure 0.2 to 0.25 mm. long.

Madreporic body variable in size, medium, situated a little nearer to margin than middle of r.

Young.—The smallest specimen has R 8 mm., and like larger examples has a thick pulpy skin, thrown into folds or welts by irregular deep creases. There are a few carinal spines and one series of superomarginals, one of inferomarginals, and one of adambulacrals, the latter well spaced from the inferomarginals. The spinelets are all slender, and the carinals are nearly obscured by the integument.

Anatomical notes.—The spinelets are fewer and the plates thinner than is usual in 6-rayed species. The primary spiniferous plates are irregularly roundish or short-lobed and are connected by from 1 to 3 overlapping, flat, spineless ossicles. (Pl. 43, fig. 2*b*.) These form the connectives of a very irregular mesh, which abactinally may be open, or fairly close. The spaces are larger toward the end of the ray than on the disk and base of arm. The superomarginal plates are larger than the inferomarginal and either three or four lobed. The latter frequently have only the dorsolateral lobes developed. They are then not connected in series, but only with the superomarginals and actinals. When the longitudinal connective is present it is quite slender.

The gonads open ventrally. The ovaries are nearly globular and are mature in an example with R 25 mm., and in another with R only 15 to 17 mm. (Agattu, June 8, 1906).

Type.—Cat. No. E 1497, U.S.N.M.

Type locality.—Humboldt Bay, Shumagin Islands.

Distribution.—From the Shumagin Islands to Attu and Agattu (at end of Aleutian chain).

Specimens examined.—Twenty-four.

Specimens of Leptasterias leptodoma examined

Locality	Depth	Number of specimens	Collection
Unga, Shumagin Islands		1	U.S.N.M., W. H. Dall.
Humboldt Bay, Shumagin Islands		4	U.S.N.M.
Unalaska	Low tide	5	Stanford, H. Heath, G. D. Hanna; U.S.N.M.
Nazan Bay, Atka Island, Aleutian Islands	do	2	U.S.N.M., W. H. Dall, 1873.
Atka Island, Aleutians	do	1	U.S.N.M.
Adakh Island, Aleutians	do	1	Do.
Attu Island, Aleutians	do	1	Albatross, June 10–11, 1906.
Agattu Island, Aleutians	Shore rocks	9	Albatross, June 8, 1906.

Remarks.—*L. leptodoma* is notable for the pulpy, welted integument, very irregular, almost papery, abactinal skeleton, and few abactinal spinelets and pedicellariae. It may be distinguished from other small 6-rayed species by the three regular lateral longiseries of marginal and actinal spinelets and by the very few small abactinal spinelets.

The well-developed actinal plates differentiate the species from any of the forms of *alaskensis;* while the absence of any carinal differentiation prevents confusion with the various forms of *hexactis*, notably forma *aspera* which has rather heavy pulpy skin.

LEPTASTERIAS HEXACTIS (Stimpson)

Plate 44; Plate 45, Figure 2; Plate 50, Figure 7; Plate 51; Plate 52; Plate 54, Figure 6.

Asterias hexactis Stimpson, Proc. Boston Soc. Nat. Hist., vol 8, 1862, p. 272. —Verrill, Trans. Conn. Acad. Sci., vol. 1, 1867, p. 326.—Bell, Proc. Zool. Soc. London, 1881, p. 495.

Leptasterias hexactis Verrill, part, Shallow-water Starfishes, 1914, p. 126, pl. 25, figs. 7, 8 (type).

Leptasterias epichlora alaskensis var. *siderea* Verrill, Shallow-water Starfishes, 1914, p. 137, pl. 16, figs. 3, 4 (Yakutat Bay).

Leptasterias epichlora miliaris var. *regularis* Verrill, Shallow-water Starfishes, 1914, p. 139 (Cape Fox, Alaska).

Leptasterias epichlora plena Verrill, Shallow-water Starfishes, 1914, p. 140, pl. 58, fig. 1 (Comox or Sooke, British Columbia).

Leptasterias epichlora var. *plena* Verrill, Shallow-water Starfishes, 1914, plates, p. 118.

Leptasterias epichlora pugetana Verrill, Shallow-water Starfishes, 1914, p. 142 (Puget Sound).

Diagnosis.—A small 6-rayed, polymorphic species, allied to *camtschatica*, having slender to robust rays, a well developed actinal series of plates, irregular dorsal spinulation, one to five (according to forma) superomarginal spinelets, and usually well differentiated carinals. Differing from *alaskensis* in having a long series of actinals, a narrow dorsolateral area, conspicuous carinal series, superomarginals higher on side of ray, and in lacking conspicuous bivalved pedicellariae.

Heretofore the name *hexactis* has been applied to almost any small 6-rayed *Leptasterias* with slender rays and relatively few spinelets. Verrill reproduced Stimpson's original description but his own published observations were confined to specimens of *L. pusilla* from Monterey. What his "numerous specimens from Puget Sound and the Queen Charlotte Islands" may have been I have no way of knowing, since they can not be located. Certainly duplicates of Stimpson's puzzling types are not common in that region.

It is necessary to repeat that among the numerous small 6-rayed sea stars of the northwest coast of America specific lines are exceedingly difficult to draw; but nowhere is there such a confusion and intermingling of forms as in the sounds of Washington and British Columbia. Specific lines which are fairly distinct elsewhere here break down and one of the reasons is probably hybridization, as suggested by the presence of a minority of intermediate and freakishly aberrant specimens. Hybridization would be likely and simple enough if the breeding seasons coincide; but it is difficult to prove that it takes place.

I have used *hexactis* in a different and much broader sense than has Verrill, to include the common 6-rayed *Leptasterias* of the Puget Sound region having irregular abactinal spinulation, a fairly regular and narrow carinal band of spinelets, and usually monacanthid or diplacanthid superomarginals (forma *regularis*). This ranges from Cape Flattery to Kodiak Island, while an intergrading paucispinous variation (*aspera*) can be traced as far as the Shumagin Islands. A multispinous form (*plena*) appears to intergrade with both forma *regularis* and *hexactis* in the Puget Sound region; while its northern counterpart, forma *siderea*, intergrades with *regularis* and probably also with *L. camtschatica dispar* (through forma *nitida* at Kodiak).

I have studied Stimpson's type and type series. Probably if an attempt had been made to find the most puzzling specimens in the Puget Sound region no better selection could have been made. The type series, No. 1368, contains three examples of forma *hexactis* with R 32 to 40 mm. (pl. 51, figs. 2, 3), a small relatively stouter-rayed specimen with R 20 mm., and monacanthid superomarginals, referable to forma *regularis* (pl. 51, fig. 1) and 14 equally small, stout-rayed examples of a subform of *plena* (figs. 5–9). Whether these were collected together is not known, but it is very probable.

In the original description, reproduced by Verrill, Stimpson has incorporated some of the characters of these small *plena*, as, for instance: "In some specimens the lateral spines are distinct from the ventrals, being separated from them by a channel, and forming a crowded row of *confluent clusters* like the dorsals. Dorsal spines small and numerous, in little heaps, which being confluent in a longitudinal direction form three or five (according to the distance from the disk) rows, separated from each other by corresponding rows of papuliferous depressions." This refers to small *plena* having R about 20 mm. such as Plate 51, Figures 6, 8; Figure 5 is somewhat intermediate with *regularis*. In the following sentence he says: "These spines in some specimens, however, are fewer and do not form heaps." This refers to the type and two cotypes; Figures 2, 3.

The relationships of *hexactis*, in the narrow sense, are very obscure. I doubt if there is a homogeneous forma *hexactis*. These gaunt, rather paucispinous specimens with one or two superomarginal and rather few irregular, dorsolateral spinelets behave like fortuitous variations, probably of forma *regularis*. The small specimen (pl. 51, fig. 1) in the type series suggests this and I have what are apparently a few variants of *regularis* (San Juan Island) which resemble the cotypes of forma *hexactis*. They appear to me to be something distinct from the paucispinous forms of *vancouveri*, for instance.

After *camtschatica*, the name *hexactis* has priority for any 6-rayed *Leptasterias*. It is unfortunate, therefore, that the types are what they are. I believe, however, that the relationship of this series of specimens is with forma *regularis* and not at all with *aequalis*, despite the peculiar behavior of *vancouveri*. Both *regularis* and *hexactis*, among other items, lack the two or three enlarged lateral teeth of the terminal lip of the crossed pedicellariae, such as are characteristic of *aequalis*. This is an insignificant character but in the almost hopeless mess of 6-rayed forms in the Puget Sound region, everything helps.

No adult specimens with slender rays (forma *hexactis*) have been taken north of Boundary Bay (between Washington and British Columbia) which is another curious fact. As forma *regularis* is the prevalent variety of *hexactis*—the species—in the Puget Sound region, so also forma *regularis* and its less spiny counterpart, forma *aspera*, are the predominant types over the extensive coast between Boundary Bay and the Shumagin Islands. Forma *siderea* and *plena* are not so common, unless possibly on more exposed outer shores.

The picture of the species *hexactis* should be based upon *regularis* and *aspera* (which are really subformae of a variable forma) rather than upon forma *hexactis* which is a rare, problematical variation. The fact that the type of the species is what it is constitutes an unfortunate episode in the taxonomic history of *Leptasterias*.

Forma HEXACTIS (Stimpson)

Plate 44, Figures 1, 1*a*–1*f*, 5; Plate 50, Figure 7; Plate 51, Figures 2, 3

Superomarginal spinlets two or one, sporadically a group of three; inferomarginals usually one. Rays slender, fairly long and attenuate distally; abactinal spinelets cylindrical, tapered or slightly clavate, well spaced; a fairly regular carinal series of single spinelets or of groups of two or three (occasionally four or five); dorsolateral spinelets usually one, sometimes two to a plate proximally forming two irregular longiseries and distally one, or in extreme cases one only throughout. In this case there are a few scattered spines at base of ray. One series of actinal spinelets extending one-half to three-fourths length of ray. Crossed pedicellariae with the last external tooth of terminal lip sometimes slightly enlarged; straight pedicellariae triangular ovate to slender ovate, or triangular lanceolate. R 41 mm., r 8 mm., r=5 r.

Specimens examined.—Stimpson's types, three specimens, No. 1368, U.S.N.M.; Puget Sound, two specimens, Plate 50 Figure 7, Stanford collection; San Juan Islands, Wash., Stanford collection, one specimen; Boundary Bay, British Columbia, Stanford collection, six specimens.

Forma ASPERA, new forma

Plate 44, Figures 4, 4*a*–4*c*; Plate 45, Figures 2, 2*a*; Plate 51, Figure 4; Plate 52, Figure 6

Diagnosis.—Differing from forma *regularis* with which it freely intergrades in having relatively few dorsolateral spinelets; usually a definite adradial and supramarginal band free of spinelets; typically a single series of superomarginal, inferomarginal and actinal spinelets; adambulacrals monacanthid; rays six, robust, typically with a thick skin; papulae large. R 43 mm., r 13 mm., br. 13 mm., R = 3.3 r (St. Paul, Kodiak).

In this paucispinous, but robust phase of *hexactis* there are extreme specimens with a single prominent carinal series of usually contiguous subcylindrical truncate or subcapitate spinelets; a single zigzag series of widely spaced dorsolaterals with a few scattered spinelets at base of ray; superomarginals in one regular series, inferomarginals in one or two; actinals in one series; meshes of abactinal skeleton rather open. Then there are others in which accessory smaller carinal spinelets are added on some of the lateral lobes of the plates, usually on the proximal part of ray only. (This phase of spininess corresponds to that of *Pisaster brevispinus* forma *paucispinus.*)

These specimens when dried have a rather rough, meager appearance in spite of the stoutness of the rays. Owing to the thornlets of the spines the surface is raspy.

Typical specimens are found at Nagai, Shumagin Islands; Kukak Bay, Shelikof Strait; St. Paul, Kodiak; Litnik Bay, Afognak Island; Prince William Sound (Cordova); Port Etches, Alaska; Funter Bay, Lynn Canal; Wrangell; WhiteWater Bay, Alaska; and Alert Bay, Vancouver Island.

Well developed types from St. Paul, Kodiak Island, have a regular prominent series of close-set, subcapitate, striate, unequal, carinal tubercles. The dorsolateral area is very irregularly beset with relatively few, widely spaced, unequal tubercles becoming sometimes transverse groups of three or four. These increase in number by interpolations until a broken areolated pattern of *regularis* is achieved. Some of the dorsolateral tubercles are conspicuously heavier than the carinals or they are subequal. There is usually a well-defined bare zone above the regular single series of subcylindrical or tapered superomarginals. The latter define the dorsolateral margin of ray. Frequently there is a similar adradial channel. Intermarginal channel well marked. Inferomarginal spinelets usually one, sometimes two, tapered, blunt, a little longer and heavier than upper series; actinals similar to above extending in a single series far along ray. Adambulacral spinelets subclavate, about as long as actinals, but much slenderer, gradually lengthening on first 6 to 10 plates; beyond base of ray the alternates are slenderer and more advanced into furrow; mouth plates with fairly well developed actinostomial spine, about as long as plate; occasionally a second small companion; suboral longer than first adambulacral and actinostomial.

The specimens from Kukak Bay, Shelikof Strait, Alaska, are notable for having unusually slender ossicles and large papular areas. The spinelets are weaker than normal and straight pedicellariae small.

Specimens from the vicinity of Cordova, Prince William Sound, exhibit an uninterrupted series from typical *aspera* to paucispinous examples of *regularis.* Some specimens of both forms have well developed ovoid straight pedicellariae on the abactinal, lateral, and actinal surfaces. The skeletal meshes are large.

Alcoholic examples usually show a pulpy skin, prominent sheaths around the spinelets, and large papulae. This is particularly true of southern Alaskan and Alert Bay examples, but is not of geographic significance since the Nagai and Afognak specimens are similar.

Crossed pedicellariae not very numerous, 0.19 to 0.25 mm. long. (Pl. 44, fig. 4*a*.) In northern examples the lateral teeth of the terminal lip are characteristically slender. Straight pedicellariae ovate, slender ovate, tapered, the tip of jaw either narrowed or slightly spatulate; largest in interradial channel, sometimes (Cordova) fairly conspicuous. (Pl. 44, figs. 4*b*, 4*c*.)

Specimens collected at St. Paul, Kodiak, April 12, 1926, by Mr. S. P. Smith, were carrying large masses of eggs on the oral side of disk.

Color in life.—Specimens from Kodiak (St. Paul) only a month in formalin, were colored dull maroon, sometimes very deep, mottled with cinnamon or pinkish cinnamon.

Type of forma aspera.—Cat. No. E 1498, U. S. N. M. (from Hopkins Marine Station).

Type locality of forma aspera.—St. Paul (Kodiak), Kodiak Island.

Distribution.—Nagai, Shumagin Islands to Alert Bay, Queen Charlotte Sound, British Columbia.

Forma REGULARIS Verrill

Plate 44, Figure 6; Plate 51, Figure 1; Plate 52, Figures 3–5

Leptasterias epichlora miliaris var. *regularis* Verrill.
Leptasterias epichlora miliaris var. *subregularis* Verrill.
Leptasterias epichlora pugetana Verrill.

Diagnosis.—Differing in appearance from *L. alaskensis* in having a long series of monacanthid actinal plates; a well marked carinal series of small groups of spinelets; superomarginals well up on side of ray; small to medium sized ovate or ovate-lanceolate straight pedicellariae; mostly monacanthid adambulacral plates. Superomarginal spines one or two (sporadically three); inferomarginals two; a well developed inter and supra marginal channel. Rays six, rather short and robust; skeleton stout, irregular dorsolaterally; dorsolateral spinelets rather numerous, and coarse, scattered or forming a poorly defined reticulum.

This is one of the few forms of *Leptasterias* described by Verrill of which authentic specimens can be found. I have carefully examined one from Cape Fox, the only listed locally. This is on the mainland opposite the northern end of the Queen Charlotte Islands.

The Cape Fox example has rather fewer abactinal spines than the majority of the specimens from the Puget Sound region and certain similar ones from Sitka, Loring, and Homer, Alaska, to which Verrill's name *pugetana* would be applicable. This subspecies was based upon an example from Puget Sound having the unusually large ovoid pedicellariae which are found also on some specimens of undoubted *regularis* (Cordova, Alaska; Victoria, British Columbia). *Pugetana* simply represents a more multispinous phase of *regularis* and occurs among specimens from Cooks Inlet, Alaska, to Neah Bay, Washington.

Verrill's specimen of *regularis* is therefore a rather paucispinous example of forma *regularis*. It is necessary to correct a serious error in Verrill's short diagnosis of variety *regularis* (1914, p. 139). He says: "The *second* short interactinal row of ossicles bearing spines is not present, as it is usually in other varieties when of the same size, and this is probably the cause of the slenderness of the ray." A second series of actinal ossicles occurs in well-developed specimens of *camtschatica* and *aequalis* but never in the *alaskensis* series, and never, so far as I have observed, in *hexactis*. Verrill more than once mistook young *Evasterias* for 5-rayed examples of some of his varieties (as, var. *subnodulosa* 1914, p. 139). These have regularly two series of actinals. Verrill's *Leptasterias macouni* is an *Evasterias*.

The largest specimens which I have seen were collected by Mrs. Ida S. Oldroyd at Friday Harbor, San Juan Islands, Wash. (pl. 52, fig. 3). Rays medium slender to medium robust; R 39 mm., r 12 mm.; ray width 9 to 11 mm.; rays rather blunt and stubby, sometimes inflated. Abactinal spinelets, stout, subcylindrical to subcapitate truncate, arranged in irregular broken reticulum, the carinals forming an irregular multiple series—three to six spinelets per plate; dorsolaterals two or three to six to a plate. Papular areas in the equivalent of six abactinal longiseries, only those above superomarginals being at all regular; three to six abactinal papulae to an area.

Superomarginal spinelets two, sometimes three to a plate proximally, sporadically one. Inferomarginals proximally one, then two; actinals one, these forming a transverse comb of two or three with the inferomarginals. They are subcylindrical or tapered, blunt, sometimes upturned at end. Adambulacrals with one spinelet except near base of ray where for a short distance there are one and two. Oral plates with one actinostomial spinelet a little shorter to a little longer than plate and one suboral a trifle longer than proximal adambulacral spinelets.

Straight pedicellariae ovate or triangular ovate, compressed, the end of jaw with sometimes two or three denticles. Good sized ones measure 0.4 to 0.5 mm. Crossed pedicellariae not very abundant, the abactinal 0.2 to 0.22 mm. long. They are not particularly diagnostic. (Pl. 44, fig. 6.)

Three specimens from the vicinity of Victoria have mostly monacanthid superomarginals, while the others have two or three spinelets. The straight pedicellariae are sporadically larger, or more numerous, in certain specimens. Such examples formed the basis for Verrill's *Leptasterias epichlora pugetana*.

Type of forma regularis.—In Yale Museum.

Type locality of forma regularis.—Cape Fox, Alaska (opposite Dixon Entrance).

Distribution.—Puget Sound and Vancouver Island to Cooks Inlet. The northern examples are less spinous than the southern and less easy to differentiate from *aspera* which predominates in the north.

Forma SIDEREA Verrill

Plate 44, Figures 2, 2*a;* Plate 51, Figure 1; Plate 52, Figures 1, 2; Plate 54, Figure 6

Leptasterias epichlora alaskensis var. *siderea* Verrill.

Diagnosis.—Differing from forma *regularis* in having still more numerous abactinal spinelets which are usually crowded into an areolated pattern; superomarginal spinelets two or three as against usually one of northern examples of *regularis;* straight pedicellariae small lanceolate or ovate lanceolate.

This is still spinier than f. *regularis* and seems to be a northern counterpart of f. *plena*. *Siderea* occurs at Karluk, Kodiak, with a variety of *L. camtschatica* f. *nitida* which it resembles, and with which it possibly intergrades. The two forms are evidently very closely related. *Siderea* differs in having the dorsal spinulation more areolated, without longiserial arrangement. A comparison of Plate 52, Figures 1, 2, with Plate 50, Figure 1, will answer better than detailed description. This variety of *nitida* may constitute an intergrading subforma since no large typical *nitida* has been found at Kodiak.

Verrill's type of *siderea* is lost but his figure is duplicated by a specimen from Karluk, Kodiak Island. (Pl. 52, fig. 2.) The abactinal spinelets are medium robust, capitate, rather truncate, 0.4 to 0.6 mm. long, and the vertical ridges are armed with flattened often leaflike thornlets similar to those of *L. aequalis*. Spinelets not so prominent along the carinal line as in the Middleton Island specimen. The adambulacral spinelets are robust, clavate, irregularly one and two, or only one to a plate; actinal spinelets still stouter and a little longer; inferomarginal spinelets subequal to actinals; superomarginals intermediate between inferomarginals and abactinals. The apical mouth spines are stout, about as long as plates. Straight pedicellariae rather inconspicuous, elliptical ovate to lanceolate ovate, compressed. The crossed pedicellariae (0.22 mm. long) do not have comspicuous teeth on border of terminal lip.

Two specimens from Anchor Point, 20 miles west of Homer, Cooks Inlet, are remarkable for their large size. The larger has R 80 mm., r 18 mm., ray width 20 mm. These specimens do not have the maximum number of dorsolateral spinelets, which are coarse and sometimes tubercular; and the proximal superomarginals have sometimes only one spine, while the distals have two. Straight pedicellariae rather plump, lanceolate to ovoid. These specimens may be classified either as multispinous *regularis* or as less spiny *siderea*.

Type of forma siderea.—Lost.

Type locality of forma siderea.—Not stated; Yakutat, one of the localities mentioned by Verrill, may be designated.

Distribution.—Kodiak Island and Middleton Island to Yakutat Bay.

Forma PLENA Verrill

Plate 44, Figure 3; Plate 51, Figures 5–9; Plate 52, Figure 7

Leptasterias epichlora plena VERRILL.
Leptasterias epichlora var. *plena* VERRILL.

Diagnosis.—A southern more multispinous counterpart of *siderea* which differs in having the abactinal spinulation somewhat more clumped, the groups of spinelets sometimes subdivided into five very irregular multiple longiseries of spinelets by six irregular longiseries of papular depressions; superomarginals three to five usually unequal, in a vertical series or a group; occasionally six or seven on a few proximal plates and two on distal; inferomarginals two or three; actinals one; adambulacrals one and two in alternation over most of ray; a few proximal plates sometimes consecutively diplacanthid; furrow spinelet of diplacanthid plates slenderer than the others which are subcylindrical to clavate. R 40 mm., r 12 mm., br. 12 mm., R=3.3 r (Forrester Island).

This group ranges from Puget Sound to southern Alaska and probably intergrades with *siderea* which it much resembles. It also suggests a coarse spined form of *L. aequalis* with indefinite abactinal longiseries of spinelet groups. The spinelets are like those of *siderea* in size and structure.

Straight pedicellariae longer than broad, triangular lanceolate or lanceolate ovate, similar to those of *siderea*. Crossed pedicellariae (pl. 44, fig. 3), with the lateralmost tooth of terminal lip slightly enlarged.

I have examined Verrill's type which is figured (1914, pl. 58, fig. 1). The specimens from Forrester Island resemble the type, which is said to be from either Comox or Sooke, Vancouver Island. Practically all the other specimens I have seen from the Puget Sound region, including those in the type series of *hexactis*, are small (R 10 to 26 mm.), and easily confused with small *L. aequalis*. (Pl. 51, figs. 5 to 9.) It is a hopeless task to differentiate such confused forms by words. However, these small *plena* differ from *aequalis* in having fewer, coarse spinelets, the coordinated groups being more irregular; or else the abactinal spinelets are arranged in a close reticulum. Both phases differ from *regularis* in the more numerous abactinal spinelets and the presence of three to five superomarginal spinelets in an angular series or a group. (Puget Sound; Alert Bay, Vancouver Island.) Two or three specimens of Stimpson's type series of *hexactis* (1368 *a*, *b*) stand between these depauperate *plena* and the actual type specimens, while one (1368 *d*), is intermediate with *regularis*.

Type of forma plena.—Victoria Memorial Museum, Ottawa.

Type locality of forma plena.—"Sooke or Comox, B. C." (label of type specimen).

Distribution.—Puget Sound region, Vancouver Island, and southern Alaska.

Type of Leptasteriae hexactis.—No. 1368, U.S.N.M., Dr. C. B. Kennerly.

Type locality.—Puget Sound, Wash.

Distribution.—Shumagin Islands to Cape Flattery, Wash., chiefly intertidal: to 25 fathoms in the Puget Sound region.

Specimens examined.—Three hundred and twenty-two.

Specimens of Leptasterias hexactis examined

Locality	Number of specimens of forma—					Collection
	hexactis	*aspera*	*regularis*	*siderea*	*plena*	
Nagai, Shumagin Islands		1				U.S.N.M.
Kukak Bay, Shelikof Strait		7	[1]1			Stanford, H. C. McMillin.
Kodiak Island		1	[1]1			Coll. Wosnessensky, 1858, from Acad. Sci., U. R. S. S.
St. Paul, Kodiak Island		58				Stanford, S. P. Smith; U.S.N.M., W. J. Fisher.
Karluk, Kodiak Island				7		Stanford, C. Rutter.
Afognak Island		1				U.S.N.M., Albatross.
Middleton Island, Gulf of Alaska			1	4		U.S.N.M., W. H. Dall.
Port Graham, Cooks Inlet			[1]2			U.S.N.M.
Seldovia, Cooks Inlet			[1]2			Do.
Homer, Cooks Inlet				[2]2		Do.
Cordova, Prince William Sound		[1]17	[1]6			Stanford, A. W. Greeley, H. C. McMillin.
Observation Island, Cordova		[1]2	1			U.S.N.M.

[1] Some specimens more or less intermediate between *aspera* and *regularis;* not extremes of either forma.

[2] See note under *siderea;* somewhat intermediate with *regularis*.

Specimens of Leptasterias hexactis examined—Continued

Locality	Number of specimens of forma—					Collection
	hexactis	*aspera*	*regularis*	*siderea*	*plena*	
Port Etches, Alaska		[1] 5				U.S.N.M., W. H. Dall.
Funter Bay, Lynn Canal		2	[1] 1			U.S.N.M., Albatross.
Sitka, Alaska			9			Stanford; U.S.N.M.
Wrangell, Alaska		28	[1] 4			U.S.N.M., W. H. Dall, W. H. Jones.
Loring, Alaska			3			U.S.N.M.
Security Bay, Alaska		1				U.S.N.M., W. H. Jones
White Water Bay, Alaska		2				Do.
Cape Fox, Southeast Alaska			1			Yale, W. R. Coe.
Forrester Island, Southeast Alaska					7	Stanford, H. Heath.
Fort Rupert, Vancouver Island			[1] 8			U.S.N.M., Harlan Smith.
Alert Bay, Vancouver Island		14	[1] 18		2	Stanford; U.S.N.M.
Vancouver Island (Comox or Sooke)					1	Victoria Memorial Museum.
Boundary Bay, British Columbia	5					Stanford, F. W. Weymoutn.
Victoria, British Columbia			25			U.S.N.M., J. E. Benedict, Wm. Palmer, Albatross.
Orcas, San Juan Islands, Wash	2				3	Stanford, E. C. Starks.
San Juan Islands, Wash	[3] 15		27			Cal. Acad. Sci., shore to 25 fathoms, Ida Oldroyd.
Puget Sound	[4] 3		[5] 1		[5] 14	U.S.N.M., Dr. C. B. Kennerly.
Do			1			U.S.N.M., D. S. Jordan; Stanford, E. C. Starks.
Strait of Fuca	[6] 1		1			Stanford, Ira Cornwall; U.S.N.M., D. S. Jordan.
Neah Bay (Cape Flattery), Wash			4			U.S.N.M., J. G. Swan.

[1] Some specimens more or less intermediate between *aspera* and *regularis*; not extremes of either forma.

[3] See under *vancouveri*. These are part of the series of *vancouveri* and are sufficiently large (R 30 mm. or more) to preclude the possibility of their being the young of multispinous *vancouveri*. 3 specimens are pretty clearly intermediate with *regularis*.

[4] No. 1368, U.S.N.M., type and 2 paratypes.

[5] No. 1368, U.S.N.M., part of type series of *Asterias hexactis*.

[6] William Head west of Victoria. This is similar to the most regular of the San Juan Islands version of *hexactis*.

LEPTASTERIAS HEXACTIS VANCOUVERI (Perrier)

Plate 45, Figures 1, 1*a*–1*e*; Plate 46, Figure 1; Plate 53

Asterias vancouveri Perrier, Rév. des Stell., 1875, p. 64; Ann. and Mag. Nat. Hist., ser. 4, vol. 17, 1876, p. 35 (Vancouver Island).

Leptasterias vancouveri Verrill, Shallow-water Starfishes, 1914, p. 125.

Diagnosis.—Rays six. A problematical and very variable form, in its extreme development resembling a coarse-spined *L. aequalis* but practically intergrading with *L. hexacitis*. Rays moderately stout, tapered; spinelets typically arranged, by groups or singly in longiseries; carinals three to five, dorsolaterals one to three, superomarginals two to five, inferomarginals two to one, actinals one per plate (two series proximally); dorsolateral area typically narrow; superomarginal plates broad, with typically three, four, or five spinelets in a vertical comb; usually six longiseries of dorsal papular areas.

I examined Perrier's type in the British Museum. It is one of the extreme, more multispinous variations of the race having prominent regular carinal plates, fairly regular dorsolaterals and four or five superomarginal spinelets.

I have given this extraordinary form subspecific rank in order to emphasize its peculiarities—structural, developmental, and geographic—and to free *hexactis* and *aequalis* from a further encumbrance of formae.

Its range so far as known is restricted to the general region of the confluence of the Strait of Georgia, Strait of Fuca, and Puget Sound. The large series which I have examined was collected among the San Juan Islands, chiefly by Mrs. Ida Oldroyd.

Its younger stages are different from those of *aequalis* in having fewer, more widely spaced dorsal spinelets (arranged in pretty regular longiseries). Its structural peculiarities concern the wide range of its variations. These variations include a few specimens which appear to be intermediate with *L. hexactis* f. *regularis*, which occurs with *vancouveri* at the San Juan Islands. Other extermes are closely similar to *L. hexactis* f. *hexactis* as noted below.

In order to arrive at some semblance of order the specimens will be divided into groups on the basis of the number of superomarginal spinelets.

I. Superomarginal spinelets, four or five, rarely six, in a vertical series; a broad conspicuous band of these combs extending along the dorsolateral curvature of the ray (pl. 53, fig. 3); superomarginal plates broad and regular; inferomarginal spinelets longer than superomarginal, slightly curved, two proximally and one or two distally; a series of slightly longer actinal spines reaches far along ray while a second series is usually present on the proximal third or half of ray. There is a definite channel above the superomarginal spinelets and a narrow intermarginal one; in addition to the dorsolateral papulae (see below) an intermarginal and two incomplete actinal series (large examples). Adambulacral spines subcylindrical to subclavate, slender, usually two at base of ray; then one and two, or one only.

a^1. Abactinal spinelets *have the appearance* of forming fairly regular longiseries (proximally two, distally one) on either side of the regular carinal series. Spinelets short, typically robust, cylindrical to subcapitate, round-tipped to subtruncate, coarser, more widely spaced and fewer than in *aequalis* of the same size; dorsolateral spinelets one to three per plate, usually two or three; carinal spinelets three to five; usually six discernible longiseries of abactinal papulae. No small specimens.

b^1. Carinals conspicuously broadened, nearly as wide as the dorsolateral area. Dorsolateral plates very compact (one specimen only, R 60 mm., r 10 mm., br. 10.5 mm.) (Pl. 53, fig. 1.)

b^2. Carinals narrower than either dorsolateral area (pl. 53, figs. 2, 3); groups of dorsolateral spinelets (not individual spinelets) in more or less distinct longiseries separated by longiseries of papulae (six for abactinal area); rays moderately robust; 11 specimens from R 32 mm. to R 54 mm. (latter with R=5.4 r). Type of *vancouveri* belongs here.

a^2. Abactinal spinelets similar in numbers and form to a^1 but not arranged in longiseries of groups or only very indefinitely; even the carinal series of groups may lose its distinctness; irregularity largely due to papulae falling out of longiserial alignment; R 55 mm.; eight specimens, three more or less intermediate with a^1. (Pl. 53, fig. 4.)

II. Superomarginal spinelets averaging three; in some specimens being proximally four, distally three; or rather irregularly three or four; or three, with two spines on a minority of the distal plates; or three distally and two irregularly on some on the proximals; dorsolateral plates with one to three spinelets but more often one or two; frequently only one inferomarginal spine.

a^1. Abactinal spinelets arranged in fairly regular longiseries; six longiseries of papular areas in well grown examples; carinal plates all rather narrow with three to five spinelets. Differing from Ia^1 in that the dorsolateral plates carry one or two rather than two or three spinelets. Whatever factors reduce the number of superomarginal spinelets act also upon the abactinal. Fourteen specimens, R 26 to R 45 mm., including two or three intergrades with a^2. Shorter rayed, more robust specimens tend to have less regular abactinal spinelets. Twenty-seven specimens R 15 mm. to R 25 mm. and from quite selnder (R 24 mm. br. 5.5 mm.) to decidedly plump (R 23 mm.; br. 7.5 mm.) rays; dorsolateral spinelets usually solitary. Some of these are probably young Ia^1, without the adult, full complement of spinelets.

a^2. Similar to Ia^2, spines varying in coarseness; rays medium robust, none very slender; seven specimens, R 22 mm. to 42 mm. Two other specimens intermediate between a^1 and a^2 and with subcapitate, spaced spinelets coarser than in a^1 resemble *L. camtschatica*. (Pl. 53, fig. 5.)

III. Superomarginal spinelets two, sporadically three; dorsolateral plates with usually solitary spinelets, as a consequence of which the spinelets appear well spaced; carinals with usually two to three spinelets; inferomarginals usually one, sporadically two.

a^1. In the most regular examples, there are two longiseries of solitary, spaced, dorsolateral spinelets on either side of the carinal series of plates, which carry three (two to four) spinelets; six abactinal longiseries of small papular areas. Nine specimens R 28 mm. to R 42 mm., slender to medium robust rays; 42 specimens, R 7 mm. to R 25 mm., slender to robust rays. A considerable number of these are evidently young of IIa^1, or even Ia^1. (Pl. 53, fig. 6.)

a^2. Abactinal spinelets not in evident longiseries. Three variants are shown. (Pl. 53, figs. 7, 8, 9.) Figure 8 has the long rays of *vancouveri* but the abactinal spinelets are arranged much as in *L. hexactis* forma *regularis*, and many of the superomarginals are monacanthid. This and two smaller similar ones are intermediate *in appearance* between *vancouveri* and *regularis*, but whether biologically so I am unable to say. Five specimens, R 30 mm. to R 54 mm. The largest has somewhat swollen rays and three or four spinelets on a few superomarginals. There is a slight indication of serial arrangement of abactinal spinelets as in Figure 7 (lateral parts of abactinal area). Straight pedicellariae figured. (Pl. 44, fig. 5.)

In the foregoing enumeration of variations there is a pretty complete series of gradations from forms (IIIa^1) which are difficult to separate from *L. hexactis* f. *hexactis* (and others, IIIa^2, which appear to be intermediate with f. *regularis*) to one which can easily be differentiated on the basis of three or four superomarginals (II). This in turn passes without hiatus into typical *vancouveri* (Ia^1) which resembles large, coarse spined *aequalis* and is therefore quite distinct from Class III.

In Class II there is a deviation toward the small variety of *L. hexactis* forma *plena* with which the type of *hexactis* shows close relationship.

If large specimens of *vancouveri* are placed side by side with *aequalis* they may be told at a glance: *vancouveri* has coarser, less numerous abactinal spinelets (especially on the carinals). If the small phase, or young, of Class II is also the young of Ia, then the difference is even more marked, since the young of Ia, from having conspicuously fewer spinelets, are quite unlike the young of *aequalis*. In this case, the similarity between the adults of *aequalis* and *vancouveri* would result from convergence.

The mouth plates do not offer any help. The actinostomial spine is about as long as plate and usually has a small lateral companion.

Madreporic body conspicuous, about mid r. Crossed pedicellariae fairly abundant, in circlets around the abactinal and superomarginal spinelets. They are not particularly diagnostic, the enlarged tooth on outer side of lip being sometimes slightly developed, sometimes suppressed. Straight pedicellariae ovate or triangular ovate similar to those of *aequalis*. (Pl. 45, figs. 1*c*, 1*d*, 1*e*.)

Type.—In the British Museum.

Type locality.—"Vancouver Island." The specimen is so like the prevalent form from the San Juan Islands that I think it probably came from that region.

Distribution.—Puget Sound and adjacent regions of the Strait of Fuca and Strait of Georgia; shore to 60 fathoms.

Specimens examined.—One hundred and twenty-six.

San Juan Islands, Wash. (Friday Harbor and Orcas Island) intertidal; a few from 20 to 25 fathoms.

Seventy specimens of Classes I and II; 56 specimens of Class III, some of which are young of *vancouveri*, others either forma *hexactis*, or facsimiles.

Remarks.—Some of the specimens of Class III, enumerated above, are *L. hexactis* forma *hexactis* for ordinary purposes, and no diagnosis can be given which will separate them effectively from the types of *L. hexactis*. Yet some of Class III are undoubtedly the *young* of Class II, probably also of Class I (typical *vancouveri*). In all probability the type specimens of *hexactis* have nothing to do with *vancouveri*, but are variants of *regularis*. The logic therefore is that some of the specimens of Class III are genetically quite different from *L. hexactis*, although so similar in appearance.

LEPTASTERIAS PUSILLA, new species

Plate 45, Figures 3, 3*a*–3*d*; Plate 46, Figures 2, 2*a*–2*d*; Plate 54, Figure 5; Plate 55, Figures 1, 2, 7.

Leptasterias hexactis Verrill, part, Shallow-water Starfishes, 1914, p. 127 (Monterey).

Diagnosis.—Differing from the slender phase of *L. hexactis* f. *hexactis* in its constantly small size, in the different dentition of the crossed pedicellariae and different shape of the straight pedicellariae which are constantly narrow-ovate or elliptical in contour. Rays six, slender, subterete, tapering from a narrow base; disk small. R 22 mm., r 5 mm., R = 4.4 r (varying to 5 r); breadth of ray at base 5 mm. Spinelets small, slender, spaced, the carinal plates with proximally one to three and the dorsolaterals with usually one spinelet, all without serial order or else in five poorly defined longiseries; superomarginals, two, sometimes three, inferomarginals two; actinals one.

Description.—Abactinal spinelets (pl. 46, figs. 2, 2*a*, 2*b*) slender, longer than thick, terete to subclavate, thorny, one to three to a plate on disk; on rays one to three to a carinal plate; ordinarily one, occasionally two to a dorsolateral. Spinelets 0.3 to 0.4 mm. long, spaced by about their own length. They are arranged in about five not very regular longiseries of which the median or carinal, composed of groups of two or three spinelets, is not conspicuous as in *aequalis*. The dorsolateral plates occasionally carry two spinelets. In some specimens the spinelets are not arranged in definite longiseries. Size of papular areas variable. In one variety they are longer than plates of ray and the skeleton appears open, while in the other the areas are subequal to the plates or smaller. Papulae one to an area.

Superomarginal plates not conspicuous, four lobed with two slender spinelets similar to but a trifle longer than the dorsals, one on the dorsal, one on the ventral, and occasionally a third on the adoral lobe.

Intermarginal channel well marked with a series of single papulae. Inferomarginal spinelets two, the upper slender, subequal to or a little longer than the superomarginal, the lower 50 to 100 per cent longer, and much stouter, blunt. First three to five, with one spinelet. A single series of similar actinal spines extends one-half to three-fifths R. There are five fairly regular longiseries of lateral and actinal spines; two superomarginal, two inferomarginal, one actinal.

Adambulacral armature: One spinelet on first three or four plates, then two spinelets to a plate for a varying number; then alternately one and two, fairly regularly. Some specimens have diplacanthid plates extending to middle of ray or even farther. The spinelets are slender, terete, slightly clavate, round-tipped, a little smaller than the actinals. The furrow spinelet is usually slightly slenderer than the outer. First pair of adambulacrals in contact interradially and sometimes inner corner of second pair in contact.

Mouth plates (pl. 45, fig. 3*c*) with the usual three spinelets. The inner of the two actinostomial spinelets usually equals the plate in length, while the suboral is appreciably longer.

Crossed pedicellariae (pl. 46, fig. 2*d*), distributed as in *L. aequalis*, are not especially abundant, there being one to six around each abactinal spine but attached to the plate. In alcoholic specimens in which the skin is somewhat swollen they appear nearly as thick as the spinelets, but shorter. There is usually one (on some examples one to three) on each adambulacral spinelet; lacking on some spinelets.

The extreme lateral teeth of lip are not enlarged on outer side of jaw; length, 0.18 to 0.19 mm. Compare with *L. aequalis* (pl. 46, fig. 3) and *L. hexactis* f. *hexactis* (pl. 44, fig. 1*a*).

Straight pedicellariae more elliptical, less triangular in contour and relatively larger than in *L. aequalis* and *L. hexactis*. (Pl. 45, figs. 3, 3*a*, 3*b*.) They are about 0.4 mm. long and are found very sparingly in the intermarginal channel, in the actinal interradial channel, on proximal adambulacral spines and oral spines, and occasionally on proximal inferomarginal and actinal plates, while smaller ones are found along the furrow face of the adambulacral plates.

Madreporic body small, situated at middle of r and surrounded by a circle of spinelets. Striae few, relatively coarse.

Color in life: Mottled olive green and pale straw color; carmine and pale straw color; blotched with purplish red on a lighter ground.

Anatomical notes.—The skeleton (pl. 45, fig. 3*d*) in addition to one series of rather small 4-lobed carinal and on either side two series of larger 4-lobed marginals, consists in the adult of twice two series of dorsolaterals and on proximal part of ray of twice two series of actinals. The marginals are the largest plates, and the superomarginals have a prominent descending lobe. The inner row of actinals are always very inconspicuous since they do not carry spines.

Variations.—This species is less variable than *L. aequalis*. The rays are never short and stout as in some (but not all) examples of *L. aequalis* f. *nana*. They vary in the degree of slenderness. As a rule in large specimens R is about 5 r. The skeletal meshes vary from being smaller than the plates to appreciably larger. In the first case the skeleton appears to be close-knit; in the latter decidedly open. The length of the abactinal spinelets varies. Short-spined specimens are often difficult to separate from *L. aequalis* f. *nana* of equal size. The latter may have slender rays, but have more numerous closely-placed abactinal spinelets. The form of their straight pedicellariae is a fairly reliable recognition mark, but these are sometimes absent in very small specimens, and are occasionally narrower than normal in *aequalis*.

Type.—No. E 1499, U.S.N.M. (from Hopkins Marine Station).

Type locality.—Monterey Bay (Cypress Point), Calif.

Distribution.—Monterey Bay and Pillar Point (south of San Francisco Bay).

Specimens examined.—Numerous examples from Monterey Bay (Pacific Grove) and the region between Monterey Bay and Carmel Bay, Calif.

One specimen from Pillar Point, San Mateo County.

Remarks.—During January this species carries eggs and embryos clustered in the oral cavity of the actinal surface, and the tiny young leave the mother in February either before or while *aequalis* is laying. The young of the latter are ready to fend for themselves in late April or early May. There is thus a fundamental biological difference between *aequalis* and *pusilla*.

Pusilla is not unlikely an extension of *hexactis* stock southward to Monterey. But unlike *hexactis* of the north, it is comparatively homogeneous. Inasmuch as *pusilla* shows certain constant differences, it seems best to give it specific rank since *hexactis* is such a polymorphic species. *Pusilla* is a counterpart of forma *hexactis*.

Verrill used this species as a basis for his comparison of *hexactis* and *aequalis* and was hence led to erroneous conclusions as to the straight pedicellariae of *hexactis*.

LEPTASTERIAS AEQUALIS (Stimpson)

Plate 46, Figures 3, 3*a*–3*e*; Plate 47; Plate 54, Figures 1–4; Plate 55, Figures 3–6; Plate 71, Figures 2, 2*a*–2*c*

Asterias aequalis STIMPSON, Proc. Boston Soc. Nat. Hist., vol. 8, 1862, p. 273.—VERRILL, Trans. Conn. Acad. Sci., vol. 1, 1867, p. 327.

Leptasterias aequalis VERRILL, Shallow-water Starfishes, 1914, p. 128, pl. 16, fig. 8; pl. 18, figs. 1, 2; pl. 25, figs. 5, 6; pl. 56, fig. 5.—FISHER, Ann. Mag. Nat. Hist., ser. 9, vol. 12, 1923, p. 599.

Leptasterias aequalis var. *compacta* VERRILL, Shallow-water Starfishes,1914, p. 130, pl. 56, fig. 5.

Leptasterias aequalis var. *nana* VERRILL, Shallow-water Starfishes, 1914, p. 132.

Leptasterias aequalis var. *concinna* VERRILL, Shallow-water Starfishes, 1914, p. 132

Diagnosis.—Size small to medium; rays six, slender to moderately stout, arched, slightly swollen at base; abactinal and lateral surfaces compactly covered with graniform spinelets which form groups, aligned in more or less definite longiseries by small papular areas; carinal series conspicuous, with numerous spinelets; superomarginal series broad with an angular or vertical series of four to eight spinelets; inferomarginals with two longer spinelets; one long series of similar actinal spinelets; crossed pedicellariae with enlarged, external lateral tooth on terminal lip; straight pedicellariae few, small, triangular-ovate. Typical large specimen, R 52 mm., r 13 mm. R = 4 r; breadth of ray at base, 12 to 14 mm. (Pl. 54, fig. 4.)

Description.—The abactinal and lateral surfaces of the body have the appearance of being covered with a uniform close granulation. In alcoholic specimens this appears more compact by reason of the papulae and swollen sheaths of pedicellariae. The spinelets increase gradually in length from the carinal toward the superomarginal but are not precisely uniform on any one plate. They vary in length from about 0.35

to 0.7 mm. and are broader at top than at base. The finer structure is characteristic. The vertical ridges carry expanded bladelike, hyaline, sharp thornlets, more developed than those of *hexactis*.

The abactinal skeleton is compact and the groups of spinelets are usually arranged in fairly definite longiseries, frequently interrupted and often not at all regular on the dorsolateral plates. In typical specimens there is a broad carinal band of spinelets, upward of 10 to a plate, and on either side the equivalent of two dorsolateral series, that next to the superomarginals the more regular. There are three dorsolateral longiseries of papular areas, smaller than the plates. Dorsolaterals with from one to six spinelets. Plates not to be differentiated without preparation.

Superomarginals broad, the series bending upward at base of ray; plates armed with a vertical (transverse) angular series, or shallow chevron, of five to eight spinelets proximally (four or five in smallish specimens) and about five distally (two or three in small examples). Spinelets similar to but slightly larger than the dorsolaterals and usually slightly bent as in Plate 47, Figure 1*a*. The superomarginal band of spinelets is broader but less compact than the carinal.

Intermarginal channel very narrow. Inferomarginal plates with two (occasionally three) spinelets, the upper subequal to largest superomarginal spines, the lower spine usually much larger, flattened and subtruncate at tip; sometimes both are enlarged, especially distally. End of spinelets slightly upcurved. In compressed spinelets the ventral border is curved as in a broad-tipped knife, while the upper border is straight, or only slightly upcurved. Sometimes the spinelets are subspatulate. Proximal plates may carry only one spine.

One series of actinal plates extends three-fourths to four-fifths R, and each plate carries a single spine very similar to the larger inferomarginal. A second series of smaller plates, armed each with a small spine (about size of smaller inferomarginal), extends in large specimens about two-fifths to over half R, and is absent in most small ones.

Adambulacral plates variable. The plates of proximal third or half of ray have one and two spines in irregular alternation, sometimes continuing to near end of ray; or the plates of outer part have only one spine; the proximal plates, or a majority, may carry two spines while the distal are alternately monacanthid and diplacanthid, or else only monacanthid; or else all the plates are monacanthid with the exception of a few scattered diplacanthid plates proximally. In a series of monacanthid plates alternate ones have a slenderer, more tapered spine somewhat advanced into the furrow. These plates lack the outer spine of the couple. The other plates, lacking the furrow spine, carry a somewhat heavier subclavate or subspatulate spine, usually turned away from the furrow. The first two or three pairs of adambulacral plates are in contact interradially. First plate somewhat longer than second.

Mouth plates of the usual small size. For form and armature see Plate 47, Figures 2, 2*a*. While the longer of the two actinostomial spines is usually as long or a little longer than the plate, there is considerable individual variation, and specimens from Monterey Bay may have this spine considerably shorter than the plate. The suboral spines are usually a little longer than the adoral adambulacral spines.

Papulae in small areas, few to an area, but rather conspicuous in living specimens. There are about three dorsolateral longiseries, one intermarginal and two actinal.

Crossed pedicellariae (pl. 46, figs. 3, 3*a*–3*d*) with the usual distribution. They are attached to plates at base of dorsal spinelets but are not sufficiently numerous to form wreaths as in *L. hexactis*. Interrupted wreaths are present on superomarginal spinelets and small tufts on outer side of inferomarginals, actinals, and adambulacrals. The abactinal pedicellariae measure 0.19 to 0.22 mm. in length and are characterized by the increased size of the *external* lateral teeth of the terminal lip of the jaw as shown in Plate 46, Figure 3. Sometimes only one tooth is enlarged, sometimes several. The adambulacral pedicellariae have a somewhat longer lip and are slightly larger than the abactinal (0.24 mm.).

Small straight pedicellariae (pl. 47, figs. 3, 3*a*–3*d*) are found chiefly on mouth and proximal adambulacral spines, very sparsely in interradial, intermarginal, and actinal channels and just above the superomarginal plates; small pedunculate ones (0.2 to 0.4 mm.) are scattered along furrow edge of adambulacrals. They are fairly broadly triangular in contour, compressed, and the tips of the jaws may be somewhat unguiculate. They are usually very scarce outside of the ambulacral and oral plates and are never conspicuous. The largest (interradial) are about 0.5 mm. in full-grown males.

Madreporic body conspicuous, surrounded by a close palisade of spinelets; external margin at middle of r; striae fine, branching, or interrupted.

Color in life.—Large specimens are usually olive green, either uniformly dark, or dark mottled with paler green; actinal surface whitish, ashy, or pale pinkish gray; tube feet very pale translucent gray green. Small specimens may be dull rose pink or mallow purple blotched with pomegranate purple, whitish on under side; others are gray green mottled with darker olive. A medium-sized specimen of forma *aequalis:* General color of abactinal surface rich greenish brown rather faintly marbled with dark raw Siena and pale Hooker's green. The ends of fluted spinelets pale greenish yellow; pedicellariae same; papulae pale greenish to bottle green, golden at ends; madreporic body cream color; marginal spines Naples yellow becoming more and more greenish toward end of ray; tube feet Naples yellow.

Specimens collected under rocks at Port Renfrew, Vancouver Island, by Dr. John C. Brown: "Color variable, often gray browns; some are orange with gray-brown specks and blotches all over; some are light coral pink (like coralline algae)and still others are bright coral red."

Anatomical notes.—Skeleton (pl. 46, fig. 3*e*): In most specimens the skeleton of the ray consists of regular longiseries of conventionally 4-lobed or somewhat lozenge-shaped plates with the exception of the dorsolateral area where the regularity is broken. There are essentially two dorsolateral series; that adjacent to the carinals rather zigzag and separated from the second or outer by a fairly regular longiseries of papular pores. The dorsolaterals are quite regular in contour. In a few specimens examined the serial arrangement of abactinal plates was entirely broken up on the proximal half of ray. The superomarginal plates are much the broadest of any. The interbrachial septum consists of strong imbricating plates.

Forma AEQUALIS (Stimpson)

Plate 54, Figures 1, 2, 3, 4; Plate 55, Figure 6

Leptasterias aequalis var. *compacta* VERRILL, 1914, p, 130, pl. 56, fig 5.
Leptasterias aequalis var. *concinna* VERRILL, 1914, p. 132.

The typical and prevalent California form is that with fairly compact granuliform abactinal spinulation. There is a fairly regular carinal band of more closely set, numerous granuliform spinelets. A semblance of regularity is given to the dorsolateral groups on account of the frequently regular longiseries of papular pores. Both very large (R 55mm., pl. 54, fig. 4) and small examples of this phase are common. A preponderance of the largest are males. The average breadth of ray is that of the large specimen. Slightly stouter and slenderer rayed examples occur. Smaller specimens (pl. 54, fig. 2) are likely to be stouter rayed, but not invariably so. Normally, abactinal crossed pedicellariae are not abundant. A slender-rayed variant has a complete circle of crossed pedicellariae around each abactinal spinelet. Straight pedicellariae of the slenderer and broader forms, as figured, occur in this typical phase. A variant has the carinal band narrower, somewhat less regular, and the dorsolaterals less regular. It is but a short transition to specimens which, while having granuliform abactinal spinelets, show no evident serial arrangement of the groups of spinelets.

The type specimen (No. 1372, U. S. National Museum, Monterey) has R 20 mm., r 6.5 mm., and is a small example of what I have called the typical phase. It has a subregular arrangement of the abactinal granules and three or four, rarely five, superomarginal spinelets.

Verrill's var. *compacta* and var. *concinna* seem to me to be only well-developed specimens of the type form. His figure of the type of var. *compacta* indicates a small specimen although it is described as "the most perfectly developed variety of *aequalis*." It is not clear wherein it differs from var. *concinna* since both are large, have numerous spinelets, crowded on the plates, and the clusters are arranged in three to five abactinal longiseries. I have examined the type of *concinna*. "Monterey to Straits of Fuca."

Forma NANA Verrill

Plate 55, Figures 3, 4, 5

Leptasterias aequalis var. *nana*, part, VERRILL, 1914, p. 132.

For ecological work it is convenient to recognize a small form which is characterized by slender spinelets typically fairly evenly spaced without arrangement in longiseries, or with this arrangement rather vaguely indicated. There are usually only two or three slender (not short, obovate) carinal spinelets to a plate, and some few specimens (including the largest, R 31 mm., r 8 mm.) have rather numerous abactinal pedicellariae. In the largest specimen they form complete circlets around each abactinal and superomarginal spine. This specimen has four or five superomarginal spinelets, two inferomarginal, and one long and one very short series of actinals. In the more characteristic small specimens, with R upwards of 17 mm., there are three to five slender superomarginals, two very slender inferomarginals and one short series of slender actinals.

There are slender and stout rayed examples, the former sometimes difficult to separate from small specimens of *pusilla*. Certain specimens on account of their intermediate characters can not be placed definitely either in forma *aequalis* or forma *nana*. It seems probable that Verrill included young f. *aequalis* in his variety *nana*.

Both formae carry eggs while still small. I have a specimen of *nana* with R 10 mm. which carries young nearly ready to leave (March 30, 1921). Monterey.

Type of Leptasterias aequalis.—Cat. No. 1372, U.S.N.M.

Type locality.—Monterey, Calif. (A. S. Taylor).

Distribution.—San Juan Islands, Wash., and Strait of Fuca to Santa Catalina Island, Calif.

Specimens of Leptasterias aequalis examined

Locality	Number of specimens	Collection
Neah Bay, mouth of Strait of Fuca	5	U.S.N.M.
Port Renfrew, British Columbia (Strait of Fuca)	7	Stanford, J. C. Brown.
Friday Harbor, San Juan Islands, Wash	9	Stanford, F. W. Weymouth.
Crescent City, Calif	22	Stanford, C. L. Hubbs.
Fort Bragg, Mendocino County, Calif	2	Stanford, R. P. Hays.
San Francisco Bay, Calif	1	U.S.N.M., John Hornung.
Monterey Bay, Calif	Many.	Stanford, W. K. Fisher.
Cayucas, Calif	8	Stanford, Myrtle Johnson.
Santa Cruz Island, Calif	1	U.S.N.M. H. W. Henshaw.
Santa Catalina Island, Calif	2	U.S.N.M.

Remarks.—It is questionable if typical large *aequalis* reaches the Puget Sound region. The Neah Bay specimens (R 21 to 25 mm.) appear to be a variety of forma *aequalis*. The specimens from Friday Harbor have the smaller and more granuliform spinelets of *aequalis* as well as the peculiarities of the crossed pedicellariae but fewer abactinal spinelets than typical Monterey specimens of the same size (R 21 to 35 mm.) This lot of specimens is easily separable from *vancouveri*, yet any specimen from the San Jaun Islands must be viewed with suspicion and allocated with extreme caution. Something connected with environment plays havoc with specific boundaries.

It is possible that *L. aequalis* intergrades with *L. hexactis* forma *plena*, and thence through *siderea* with *L. camtschatica dispar* forma *nitida*.

LEPTASTERIAS ALASKENSIS (Verrill) emended

Plate 48, Figures 2, 3, 5; Plates 56, 57, Figures 1, 2

Asterias epichlora var. *alaskensis* VERRILL, Amer. Nat., vol. 43, 1909, p. 549.
Leptasterias epichlora VERRILL (not Brandt), part, Shallow-water Starfishes, 1914, p. 132.
Leptasterias epichlora alaskensis VERRILL, Shallow-water Starfishes, 1914, p. 136, pl. 28. fig. 1, 2; pl. 85, fig. 1–1*d*.

Diagnosis.—Rays six. Differing from *L. camtschatica* in the irregular arrangement of the abactinal spines, usually in a reticular pattern, without indication of longiseries; in the position of the superomarginals low on side of ray; in the feeble development of actinal plates which form only one series extending to middle of ray, or less; in the presence of large bivalve "stone-hammer" pedicellariae on the lateral and actinal portions of ray. R 55 mm., r 15 mm., R = 3.7 r; breadth of ray at base, 16 mm. (Unalaska).

Verrill believed, erroneously, that this species commonly includes 5-rayed examples. He apparently employed *alaskensis* in a curious way to cover the 6-rayed specimens while *epichlora* was used in a rather vague, comprehensive sense, for all the varieties combined. The type of *alaskensis* is from Unalaska (Dutch Harbor) but he cites localities from Puget Sound to the Aleutian Islands. I have never seen a 5-rayed specimen and I believe such are extremely rare in the adult state, since I have examined very many more specimens than were available to Verrill. Some of his supposed 5-rayed specimens are forms of young *Evasterias troschelii* (for example, variety *subnodulosa*).

I have restricted the name *alaskensis* to that portion of the species (of which Verrill's type is an example) which ranges from Attu Island to Cooks Inlet and probably a little further south. The range of this race corresponds closely to that of *L. camtschatica dispar*.

Verrill writes that the species has a complete series of *peractinal* ossicles each bearing one large spine and that in large specimens a short *second* row is found at the base of the rays. This is not a fact. One means of distinguishing *alaskensis*, its races and formae, from *L. camtschatica* and allies is by the feeble development of its actinal plates and spines, which never form a complete series and only in large specimens reach the middle of the ray. A *second row is never present*. The absence of a real actinal area allows the marginal plates to drop low on the side of the ray, while in *camtschatica*, *dispar*, and allies they are rather high on the lateral face of ray.

Forma **ALASKENSIS** (Verrill) emended

Plate 48, Figures 2, 2*a*–2*f*; Plate 56

The following description is of the type forma and its major variations.

Description of forma alaskensis.—Spinelets numerous, irregularly arranged in single lines surrounding the papular areas, which are unequal in size and without longiserial alignment except immediately above the superomarginal plates. Spinelets unequal, small but robust, usually quite definitely subcapitate, or capitate with a rounded or truncate, striated extremity. Those along the carinal line are likely to be more closely placed, and either subequal to the others or a trifle larger. Dorsolateral region, between the carinal and superomarginal plates, well filled in with spines which are rather evenly graded, as to length, with the superomarginals. There is a distinct tendency in specimens from Unalaska and westward for the carinal and a variable number of dorsolateral spines to form groups of two, three, four, and sometimes five, which, by reason of their slightly more prominent plates and superior size, give an uneven surface to the abactinal area (somewhat as occurs, in a more exaggerated way, in *L. polaris acervata*).

Lower on side of ray than in *L. camtschatica* is a well marked supramarginal channel and a regular double series of cylindrical, often subcapitate, round-tipped or subtruncate, but occasionally slightly tapered, superomarginal spines generally a little longer and thicker than the abactinals, or even very decidedly so. Sometimes there are three spines, but never regularly.

Below these is the regular intermarginal channel, followed by a double row of inferomarginal spines longer and heavier than the superomarginals, and in large specimens there is a *single actinal series extending less than half the length of the ray.* These actinolateral spines vary from 50 to 100 per cent longer and thicker than the superomarginals, are quite variable in form, but are generally swollen and tapered to a blunt tip; or subcylindrical; or a trifle curved; or many of the spines are compressed, of even width; or else expanded toward the tip and subtruncate (Adakh).

Adambulacral spines alternate typically one and two, fairly regularly. They are much slenderer and slightly shorter than the inferomarginals, and the furrow spine of diplacanthid plates is decidedly slenderer and more tapered than the others, which vary considerably, form a cylindrical to a terete or compressed-clavate round-tipped form. Adoral carina composed of two or three pairs of contiguous plates.

Actinostome small; mouth plates small, with three spines each—a fairly long, tapered suboral, and two apicals, of which the inner is a little longer than the median oral suture; and the outer spinelet one-half or two-thirds as long; occasionally subequal. Actinostomial margin of combined mouth plates slightly broader than the opposite margin adjacent to first adambulacrals.

Papulae in alcoholic specimens are conspicuous and appear everywhere, irregularly, among the spines and pedicellariae. The supramarginal, intermarginal, and proximally one actinal series of areas are regular. The dorsal areas are so variable in size and the number of papulae per area increases so with age that it is not possible to state any precise number of papulae. Anywhere from 3 to 12 occur in the dorsal areas of good-sized specimens, 3 to 6 in the intermarginal, and usually only 1 to 3 in the actinal.

The straight pedicellariae (pl. 48, figs. 2, 2*a*) afford one of the readiest means of identifying specimens. Characteristic bivalved pedicellariae, having subrectangular jaws a little longer than broad or slightly broader than long, of variable but large size, with the edge of the jaw denticulate, occur, sometimes abundantly, on the dorsolateral region of the ray, intermarginally, and on the actinal surface, especially in the interradial region. Sometimes the jaws are shaped like a miniature pecten shell. These pedicellariae, when well developed, have jaws 1 mm. broad, which exceeds the thickness of the abactinal spines, and even that of the inferomarginal spines, unless these are exceptionally heavy. The bivalved pedicellariae are by no means uniform in size. The largest are found at the base of the ray in the intermarginal and supramarginal channels, and actinally.

Smaller ovate and lanceolate straight pedicellariae of divers sizes occur along the furrow margin, on the oral spines, and in the clusters of crossed pedicellariae on the furrow spines of diplacanthid adambulacral plates.

Crossed pedicellariae (pl. 48, figs. 2*c*, 2*d*) are usually only moderately abundant abactinally. They are spaced, sometimes widely, around the base of the abactinal and superomarginal spines and form clusters on the outer side of the inferomarginal and adambulacral spines. The abactinal measure 0.225 to 0.24 mm. long.

Skeleton: The structural features differ from the arrangement in *L. camtschatica* as follows: Abactinal area much broader, the superomarginals being actinolateral in position; carinal series extremely irregular, sometimes not marked off from other plates; dorsolateral skeleton more open, very irregular, and plates very irregular in contour; marginal plates rather smaller with usually more attenuate lobes; actinal plates small, reaching to middle of ray; a few rudimentary spinelses plates may extend a short distance beyond middle. (Pl. 48, fig. 2*f*.)

Madreporic body situated at the middle of r, conspicuous, slightly convex, with rather fine branched radiating striae. It is encircled by a variable number of spinelets.

Variations.—Forma *alaskensis:* The typical form which has just been described is rather variable, especially in the western part of its range. A comparison of specimens from a series of localities, extending from Kodiak westward to Attu, reveals a gradual change in addition to local peculiarities.

Western examples gradually become larger and there is a tendency for the major abactinal spines to form aggregates of two to five, to become incipiently "acervate," so that the abactinal surface is uneven, not rather even as is the condition in Kodiak and most Unalaskan examples. The bivalved pedicellariae, which at Kodiak are fairly well developed, become larger and heavier, and reach their best development from Unalaska to Adakh. To the westward of Adakh they decrease in numbers and in breadth. Attu and Agattu examples in this character are intermediate with *asiatica*.

Kodiak Island: The specimens in respect to straight pedicellariae are intermediate between *L. alaskensis multispina* and *L. alaskensis alaskensis*. The lateral bivalved pedicellariae are distinctly smaller than in examples from the Aleutian Islands. Karluk examples, on the whole, have more spinelets, the superomarginals carrying two or three spinelets. (Pl. 56, fig. 2.) These specimens favor *multispina*. Some of them resemble *pribilofensis* but have narrower straight pedicellariae. St. Paul examples have fewer, more widely spaced spinelets, in common with others from Seldovia, Port Graham, Kukak Bay, and the Shumagin Islands. All these have weaker spinelets than typical Unalaskan examples, and usually only one superomarginal spinelet, but here and there two. The straight pedicellariae are smaller than normal. They intergrade freely with typical *alaskensis*. (See forma *shumaginensis*.)

Unalaska: Type locality. At Unalaska the specimens frequently have the larger abactinal spines in groups of two to four or even five, especially in the carinal series. The pedicellariae are well developed, with wide jaws and have a rounded often irregularly denticulate distal margin.

Atka: The specimens are characterized by the prominence of small *groups* of scattered abactinal spinelets and by rather greater disparity between the largest and smallest dorsal spinelets. There is considerable variation in the number of bivalved pedicellariae. The proximal inferomarginal plates usually carry only one spinelet, the distal two. The actinal series of spinelets is absent or quite short. In comparison with an average example from Kodiak, the spinulation is sparser, much coarser, and much less uniform.

Adakh: The specimens from Adakh, another island of the Andreanof group, resemble those from Atka, but there are also seven specimens taken July 5, 1893, which have the abactinal spinelets almost exactly typical. The largest has R 82 mm. Like the others, it has a typical number of marginal spinelets and the actinal series extends half the length of the ray. All the spinelets are quite stout, but the marginal and ventral especially so, these being heavy, clavate, or even clavate-spatulate. The bivalved pedicellariae are numerous and large, the jaws being very often decidedly broader than high, especially in those of the supramarginal and intermarginal channels. The distal margin is finely denticulate and is often slightly produced in the middle. This is a prolongation of a low median ridge or carina which is sometimes found on the outer face of the valve.

Amchitka Island: This is one of the Rat Islands between the Andreanof Group and the Near Islands (Attu and Agattu). The smaller of the five specimens resemble forma *shumaginensis*. The largest (R 38 mm.) has a more even surface than the Atka variety and also resembles the sparser spined intermediate specimens from Attu and Agattu. The bivalved pedicellariae are mostly smaller than typical with jaws usually higher than wide on outer half of ray.

Attu and Agattu: The specimens from Agattu (pl. 56, fig. 3), the largest of which has R 65 mm., r 18.5 mm., are rather more uniform in appearance than those from Attu (fig. 4). They represent a recognizable subrace of *alaskensis* notable for the robust abactinal spinelets which are capitate, subtruncate, and do not define the papular areas in reticulate pattern, but tend to form groups which along the carinal line are crowded and sometimes a trifle elevated (especially in young specimens). These groups occur also on the dorsolateral region but with a few exceptions are not so well defined. The straight pedicellariae are about intermediate between those of *alaskensis* and those of *asiatica*.

Numerous young specimens from Agattu (R 6 mm. to 25 mm.) have the carinal groups of two or three spinelets relatively more prominent than in large examples, while on the dorsolateral area the spinelets, of two or three sizes, are rather widely scattered. The lateral pedicellariae are thick-ovate with straight-sided or slightly tapered jaws, not greatly unlike the larger sort found in *asiatica*.

The specimens from Attu (pl. 56, fig. 4) agree with those of Atka in having considerable disparity in size between major and minor abactinal spinelets, and in having the former in prominent, though small, groups which give a very uneven appearance to the abactinal surface. This is simply an exaggeration of the condition in Agattu examples. Four specimens are practically the same as those from Atka. The others have rather coarser spinelets. The bivalved lateral pedicellariae are rather larger than in the Agattu examples, but the jaws are not so wide as in Adakh specimens, that is, are not wider than high.

There seems to be in this region (the Near Islands) a fairly definite subrace intermediate between *alaskensis* and *asiatica*, as exemplified by the majority of specimens from Agattu and some of those from Attu. Then there are (especially at Attu) a number of variants which *may* be the result of crossing of *alaskensis* with *dispar*. One evidence of this is the instability in the size of major pedicellariae; another the formation of prominent groups of carinal spinelets and the dwindling in size and number of the dorsolateral spinelets.

Forma SHUMAGINENSIS, new forma

Plate 48, Figure 3, 3*a*; Plate 57, Figure 1

These specimens differ from large, well-developed Unalaskan examples in having slenderer, cylindrical or slightly tapered spinelets which are only occasionally subcapitate. They stand not very close together on the skeletal ridges and do not form a clearly evident reticulate design. Rather they appear to stand irregularly spaced; carinal series not at all or only feebly differentiated; no acervate groups. Bivalved pedicellariae relatively narrow.

Superomarginal spinelets usually one to a plate, slightly tapered, blunt, subequal to the dorsolaterals to 50 per cent larger; spinelets well spaced, low on side of ray, much slenderer than in typical *alaskensis*. Inferomarginals proximally one or two, distally irregularly one or two or regularly two, conspicuously larger than superomarginals, typically tapered, blunt (not clavate). Actinal spines either absent or represented by a very short series, similar to inferomarginals. The small plates extend scarcely a third length of ray. Intermarginal channel proximally fairly broad.

Bivalved pedicellariae rather variable but with the jaws considerably narrower than high, and smaller than in typical *alaskensis*. In a relatively few pedicellariae the jaws are nearly as broad as high and untapered when viewed from the outer face but in the majority the jaws are tapered. (Pl. 48, figs. 3, 3*a*.)

Adambulacral spines alternately one and two; or at base of ray irregularly one and two, distally one; or less often one throughout ray (Sanborn Harbor, Nagai). Two pairs of postoral adambulacrals in contact. Oral spines three, as in *alaskensis*, but not quite so long nor so broad.

Some of the specimens from Humboldt Bay have a much weaker than normal abactinal skeleton, with relatively slender ossicles and large meshes four or five between opposite superomarginal plates.

The rays vary in caliber from slender to medium stout. Largest example R 40 mm., r 11 mm., R=3.6 r.

The variety from Seldovia, Cooks Inlet, was carrying eggs April 9, 1892.

Type of forma shumaginensis.—Cat. No. E 1500, U.S.N.M.

Type locality.—Humboldt Bay, Shumagin Islands.

Distribution.—Cooks Inlet to Shumagin Islands.

Remarks.—This is a small race or form which is found in the region between Unimak Island (where nearly typical *alaskensis* occurs) and Cooks Inlet. It intergrades with a variety of forma *alaskensis* on Kodiak, and probably elsewhere. It is none too homogeneous. The characteristic smaller spinelets, mostly monacanthid superomarginals, and smaller straight pedicellariae are best exhibited by the Shumagin Island specimens.

Forma PRIBILOFENSIS, new forma

Plate 48, Figures 5, 5*a*; Plate 57, Figure 2

This is a medium-sized rather slender-rayed variety with R averaging about 40 mm. and very numerous, uniform abactinal spinelets compactly placed and defining small, numerous papular areas. Abactinal surface evenly arched, with a regular, not lumpy surface. The spinelets are generally much more delicate than in f. *alaskensis* and very definitely form single or double palisades on the ridges of the skeleton, defining a very evident reticulate pattern on the abactinal surface. Although the spinelets are often crowded along the carinal line they do not form convex groups. This form resembles the common variety of *alaskensis* from Kodiak but the rays are slenderer and longer and the bivalved pedicellariae larger.

Among the large series there are however some short, stout-rayed examples, not differing from the above in spine characters. These have broader pedicellariae than both *shumaginensis* and the small-spined intergrades with *multispina* which are found at Karluk, Kodiak Island.

The abactinal spinelets are short, broadening toward the striate usually subtruncate tip, which is usually subcapitate and provided with numerous minute points. The superomarginal spines, two or three in a vertical series to each plate, are only a little larger than the adjacent dorsolaterals, but the inferomarginals, two to a plate are decidedly longer and heavier, and are generally cylindrical or clavate, subtruncate. There is a single short series of similar actinal spines, these with the inferomarginals forming transverse series of three at base of ray. They are from 1.3 to 2 mm. long, while the superomarginals are 0.6 to 0.8 mm., and the abactinal about 0.5 mm. long. The adambulacral spines alternate one and two.

The lateral, dorsolateral, and actinal "dermal" straight pedicellariae are of the characteristic broad jawed, bivalve, goniasterid sort (pl. 48, fig. 5*a*) generally thicker than the adjacent spines. The largest are in the supramarginal and intermarginal channels; but smaller ones occur among the inferomarginal spines. Some of these may have narrower jaws.

Color in life.—Dr. G. Dallas Hanna, who collected a large series at Village Cliffs, Village Point, and Zapadni Reef Rookery, St. Paul Island, made careful color notes and recorded 25 variations, some of them minor. The following are the principal color phases:

1. Upper surface very dark green, borders of papular areas dark brown; actinal surface and tube feet light transparent green, the margins flesh color (15 specimens).

a. Margins pink instead of flesh color (one specimen).

b. Margin of ventral surface lighter pink, and tube feet flesh color (two specimens).

c. With small bright purple spots uniformly distributed on upper surface; flesh color below, margins translucent green (one specimen).

2. Similar to 1 but upper and lower surfaces slightly lighter (10 specimens).

a. Gray muddy green above, flesh color below (2 specimens; see 12).

3. Upper surface very dark brown, papular areas black; tube feet light dirty green; furrow bordered by flesh color (14 specimens).

a. Lighter brown above, papular areas almost black (12 specimens).

b. Upper surface still lighter brown, papular areas black, tube feet dark green, lighter green, or flesh color (four specimens).

c. Dark brown all over (one specimen).

4. Upper surface dark buff; papular areas small, jet black; tube feet dirty green bordered by flesh color (one specimen).

a. Lighter buff above; actinal surface all flesh color (two specimens).

5. Upper surface purple, sides brown; actinal surface flesh color (one specimen).

6. Upper surface brick red all over; tube feet light dirty green bordered by pinkish flesh color (two specimens).

7. Upper surface light red with a few irregular blotches of blood red (one specimen).

8. Upper surface lavender (one specimen).

a. With a few little spots of dark red (one specimen).

9. Upper surface maroon (two specimens).

10. Upper surface very dark purple; under surface flesh color (one specimen).

11. Upper surface very dark blood red with dirty blotches (one specimen).

12. Light gray above, with dark spots which become merged into a large area in the center of the disk; flesh color below (four specimens).

Type of forma pribilofensis.—Cat. No. E 1501, U.S.N.M.

Type locality of forma pribilofensis.—St. Paul, Pribilof Islands, rocks, low tide.

Type of Leptasterias alaskensis.—Not present in Yale Museum collection, 1927.

Type locality of Leptasterias alaskensis.—Dutch Harbor, Unalaska (Harriman expedition). The type locality is not designated in the text, but on page 172, opposite Plate 85, is said to be Dutch Harbor.

Distribution.—Attu and Agattu (more or less intermediate with *asiatica*) to Kodiak Island and Cooks Inlet, Alaska, intertidal to six fathoms.

Specimens examined.—Four hundred and twenty.

Specimens of Leptasterias alaskensis examined

Locality	f. *alaskensis*	f. *shumaginensis*	f. *pribilofensis*	Collection
Kodiak Island	1			Acad. Sci. U. R. S. S., Wosnessensky, 1858.
Karluk, Kodiak	[1] 56			Stanford, C. Rutter.
St. Paul, Kodiak		[1] 12		Stanford, C. Rutter; S. P. Smith.
Seldovia, Cooks Inlet		11		U. S. N. M., Albatross, 1892.
Port Graham, Cooks Inlet		3		U. S. N. M., 1872.
Chignik Lagoon, Alaskan Peninsula	1			U. S N. M.
Kukak Bay, Shelikof Strait		5		Stanford.
Unga, Shumagin Islands		1		U. S. N. M., W. H. Dall.
Humboldt Bay, Shumagin Islands		30		U. S. N. M., Albatross.
Nagai, Shumagin Islands		8		Do.
Unimak Island, Alaska	5			Stanford, C. H. Gilbert.
St. Paul, Pribilof Islands			112	U. S. N. M., Stanford; Wm. Palmer, G. D. Hanna, H. Heath.
Unalaska	40			U. S. N. M., Albatross; Stanford, H. Heath.
Atka, Aleutian Islands	46			U. S. N. M., Albatross.
Adakh, Aleutian Islands	16			Do.
Amchitka, Aleutian Islands	8			U. S. N. M., W. H. Dall.
Agattu, Aleutian Islands	30			U. S. N. M., Albatross.
Attu, Aleutian Islands	35			Do.

[1] More or less intermediates.

LEPTASTERIAS ALASKENSIS ASIATICA, new subspecies

Plate 48, Figures 1, 1*a*–1*d*; Plate 57, Figures 3, 4, 5

Diagnosis.—Similar to *L. alaskensis* but the broad bivalved pedicellariae of that form represented by narrower-jawed ovoid ones. Abactinal spines numerous, of rather uniform length, robust, subcapitate, arranged in a recticular pattern. R 55 mm., r 15 mm. R=3.7 r; breadth of ray at base, 15 mm.

Description.—The spines are robust, the superomarginal and abactinal being capitate and subtruncate, with striate tips. The abactinal spines are generally of uniform, or nearly uniform length, though of different sizes and rather compactly placed, outlining the small papular areas and forming an irregular reticulate pattern.

The carinal spines are not typically larger than the dorsolaterals although more numerous to a plate, and in some but not all specimens they form an irregular band due to greater crowding. The spines do not form conspicuous, often elevated groups as in Atka and Adakh, and most of Attu and Agattu examples of *alaskensis*. There are typically two superomarginal spines, two inferomarginals (on the first three or four plates, one) and a short series of actinals (scarcely reaching the middle of R). The first three or four superomarginals may have three spines, or only one; the distals sometimes have three. The inferomarginals are heavier than the superomarginals, sometimes terete, sometimes slightly clavate. On the outer part of the ray the lower spine is usually heavier than the upper, or the upper two, for three occasionally occur.

Adambulacral spines one and two, in fairly regular alternation, and very similar to those of *alaskensis*. Three adoral pairs of adambulacral plates are in contact interradially. The oral plates are also similar to those of *alaskensis* and the outer of the two apical marginal spines is frequently absent.

The straight pedicellariae (pl. 48, figs. 1, 1*a*–1*d*) are of the common compressed ovate form, and are smaller than the broadly wedge-shaped ones of *alaskensis*. In some pedicellariae the jaws, as seen from the back or outer side, taper narrowly to a blunt or acute point (fig. 1*a*) while in others (usually near the base of ray or in axillary channel) the jaws are untapered, sometimes slightly constricted at the middle, and end in two to four teeth (fig. 1*b*). These are more common in Medni examples, and are intermediate with the pedicellariae of *alaskensis*. Small ovate and lanceolate pedicellariae occur in clusters on the oral spines, among the crossed pedicellariae of the furrow spines and on the furrow face of the adambulacrals. The latter are the smallest of all.

Crossed pedicellariae distributed as in *alaskensis*. They vary considerably in number.

Madreporic body as in *alaskensis*, surrounded by a complete circle of spinelets.

Variations.—It is to be noted that the straight pedicellariae of Medni examples are more variable than are those of Bering Island specimens. Abactinal straight pedicellariae are very scarce outside of the supramarginal channel, and the number of marginal and actinal ones is quite variable. In the arrangement of the abactinal spines there is much less variation than in specimens of *alaskensis* from Attu and Agattu. The abactinal surface of *asiatica* resembles that of some stout-spined examples of *alaskensis* from Kodiak in which the pedicellariae are also narrower than in typical *alaskensis* from Unalaska westward. The largest specimen, from Medni, has R 62 mm. There are five specimens from Simushir, Kuril Islands, which constitute a distinguishable form (pl. 57, fig. 5), differing from typical *asiatica* in smaller size, fewer and relatively larger abactinal spines, which do not clearly define papular areas but appear scattered; and in the lateral spatulate pedicellariae of conspicuous size which occur along with ovate conical ones. This may be similar to the ordinary Kamchatkan form, of which there are no specimens.

Type.—Cat. No. E 1502, U.S.N.M.

Type-locality.—Nikolski, Bering Island, shore rocks, June 15, 1906.

Distribution.—Known from Simushir (Kuril Islands), Bering Island, and Medni Island (Commander Islands).

Specimens examined.—Sixty-six.

Bering Island (Nikolski), shore rocks, 29 specimens, June 15, 1906, *Albatross.*

Bering Island (Nikolski), 5 to 10 fathoms, stones, algae, 1 specimen, August 15 1879, Vega expedition.

Medni Island, shore rocks, 31 specimens, June 13, 1906, *Albatross.*

Simushir (Milne Bay), Kuril Islands, 5 specimens, June 23, 1906, *Albatross.*

LEPTASTERIAS ALASKENSIS MULTISPINA, new subspecies

Plate 48, Figure 4; Plate 57, Figures 6, 7

Leptasterias epichlora alaskensis VERRILL, part, 1914, p. 136.

Diagnosis.—Differing from *L. alaskensis* f. *alaskensis* of the Aleutian region in having slenderer rays, slenderer spinelets, and notably smaller bivalved straight pedicellariae. Abactinal spinelets unequal; quite slender ones associated with stouter, subclavate, scarcely subcapitate spinelets arranged in a close irregular reticular pattern or without definite arrangement; carinal spinelets not differentiated. Superomarginal spines, usually two, or one at base of ray, typically slender; inferomarginals usually two (some times one); actinals small, *sometimes wanting* and never extending beyond middle of ray. R 45 mm., r 10 mm.; breadth of ray at base, 10 or 11 mm.

This race is a southern extension of *alaskensis,* which reaches its eastern limit at Kodiak Island and Cooks Inlet. *Multispina* shows its relationship by the numbers and arrangement of the abactinal spinelets (which however are weaker) and by what might be called the relics of the characteristic bivalved pedicellariae. The position of the superomarginal plates rather low on the side of ray and the reduction of the actinals to a short series of rather inconstant development indicate a close relationship with *alaskensis.*

Description.—Abactinal surface well arched so that ray appears cylindrical with a flattened, narrow, actinal surface. Abactinal spinelets, without any regular arrangement, are very numerous, fairly slender, rather uniform in length but unequal in caliber, cylindrical, tapered, or slightly clavate but not normally capitate. Since they stand on a close irregular reticulate skeleton they show a similar pattern unless interrupted by the absence of a spine here and there. In some specimens the spinelets are shorter and of more uniform thickness.

Superomarginals generally two, or irregularly one proximally; occasionally three, slightly tapered, blunt, only a little longer than adjacent abactinals. Supramarginal channel fairly broad proximally. Inferomarginals conspicuously longer, especially the lower of the usually two spinelets; sometimes three spinelets are present forming a triangular group.

The adambulacral spinelets normally alternate fairly regularly one and two, as is so commonly the case in this genus. The spinelets are nearly as long as the inferomarginals but much slenderer, terete, slightly tapered, blunt, while the furrow spine of the diplacanthid plates is shorter, slenderer, and usually a little more tapered then the outer. The posture of the spines frequently is such that there appears to be three series along the furrow margin. The first three pairs of adoral adambulacral plates are in contact interradially while those of the fourth pair are very close together.

The first six plates usually have but one spine. The first plate is longer than the succeeding plates.

The actinostome is small and sunken as is usually the case when the adoral carina is narrow. The mouth plates, at the sutural margin adjacent to the first adambulacral plate, are produced into a sort of flange so that the combined pair is here conspicuously broader than the first pair of adambulacral plates. This character is less pronounced in some varieties. Each mouth plate has three spines, a very short one close to the actinostome, and usually bent over the beginning of the radial nerve; a second, about 50 per cent longer, stands above it (as viewed from below); and a suboral, similar to the first adambulacral spine, near the outer margin of the plate.

The abactinal papular areas, except for a fairly regular series adjacent to the superomarginals, are quite irregular in form and arrangement, and variable in number and size. Probably three or four papulae to an area would be an average. In the intermarginal areas there are three or four proximally, and in the actinal, one to three. The numbers vary so with age that they afford no taxonomic ammunition.

Crossed pedicellariae occur rather sparsely on the sheaths of the abactinal spines and in dried specimens at the base of the spines; in rather scanty wreaths around the base of the superomarginal spines, and as clusters or half wreaths on the outer side of the inferomarginal and adambulacral spines.

Straight pedicellariae: The large lateral and actinal straight pedicellariae afford the easiest means of distinguishing *multispina* from *alaskensis*. Good-sized ovate pedicellariae are present in the supramarginal, intermarginal, and actinal interbrachial channels; and also sometimes in the actinal channel, and less often on a few of the proximal inferomarginal and actinal spines. Smaller ones of the same sort are sometimes sparsely scattered on the dorsolateral plates. All are broadly ovate as seen from the side, but the back of each jaw is narrower than the height, and tapers slightly. The breadth increases gradually in specimens from more northern localities, until in typical *alaskensis* from Unalaska and the Aleutian Islands, the jaw is broader than high in well developed specimens, and the whole pedicellaria is relatively larger and heavier than in southern examples. (Pl. 48, fig. 4.) The pedicellariae have a few denticulations at the jaw tip. Other smaller, broadly lanceolate, ovate, or subtriangular pedicellariae are present on the furrow margin, furrow spines (along with crossed pedicellariae), and oral spines.

Type.—Cat. No. E 1503, U.S.N.M.

Type locality.—Wrangell, Alaska.

Distribution.—Southeast Alaska to northern Vancouver Island.

Specimens examined.—Seventeen.

Specimens of Leptasterias alaskensis multispina examined

Locality	Number of specimens	Collection
Southern Alaska	6	U.S.N.M., Dr. W. H. Jones, U. S. N.
Wrangell, Alaska	8	U.S.N.M., Dr. W. H. Jones, U. S. N.
Chasina Bay, Prince of Wales Island, Alaska	1	U.S.N.M., T. H. Streets.
Alert Bay, Vancouver Island, British Columbia	2	U.S.N.M., Dr. W. H. Jones, U. S. N., February, 1882.

Remarks.—*Multispina* intergrades with *alaskensis* in the region of Kodiak and the Shumagin Islands. It resembles forma *shumaginensis*, which, in a sense, is an intermediate stage between *alaskensis* and *multispina*, perhaps if anything a little nearer the latter. *Multispina* has more numerous abactinal spinelets and rather smaller lateral straight pedicellariae. (Compare pl. 57, figs. 1 and 6.)

Subgenus NESASTERIAS, new

Diagnosis.—Differing from *Leptasterias* s. s. in the form and small size of the crossed pedicellariae which have a very broad terminal lip; in the thick, distally broadly expanded, circumspinal sheaths; in the reduction of the adoral carina to one pair of adambulacral plates in partial contact interradially; in the incipient degeneration of the dorsal skeleton (dorsolateral skeleton a single series of ossicles usually not in connection with carinals). Gonads opening ventrally; actinal plates in 0 to 2 incomplete series.

Type.—*Leptasterias stolacantha* Fisher.

Remarks.—The curious small sea stars upon which this subgenus is based are readily recognizable by the very large obconic sheaths which surround the spines and which carry on the distal convex end numerous diminutive crossed pedicellariae. The latter are of a form which differs from that running pretty constantly through the genus *Leptasterias*, as exemplified by *groenlandica, hyperborea, arctica, mülleri, littoralis*. The sheaths remind one of those found in *Coronaster, Rathbunaster, Pycnopodia*, and *Lysastrosoma*, and are relatively much fleshier than the sheaths of *L. hyperborea* or of *L. tenera* forma *compta*.

The dorsal skeleton is beginning to disintegrate, the connectives between the single dorsolateral series and the carinals, as well as between the consecutive carinals, having largely disappeared. The abactinal integument is therefore very soft and flexible.

The adoral carina is as poorly developed as in some species of the Pedicellasterinae. Only the adcentral, or inner, two-thirds or three-fourths of the interradial margin of the first adambulacral plates are in contact. The species is therefore intermediate so far as this character is concerned, between the Asteriinae and Pedicellasterinae. It occupies somewhat the same position in the Asteriinae as *Tarsaster* and *Ampheraster* in the Pedicellasterinae. Its position in the Asteriinae is indicated by the skeletal structure and the presence of pedicellariae on the adambulacral spines, while the structure of the gonads suggests an alliance with *Leptasterias*. The distinct form of the crossed pedicellariae, however, argues for only a distant connection with typical species of *Leptasterias*. The group is not so close to typical *Leptasterias* as is the *camtschatica-polaris* section.

LEPTASTERIAS STOLACANTHA, new species

Plate13; Plate 18, Figures 4, 5

Diagnosis.—Rays five, R 32 mm., r 5.5 mm., R = 5.8 r; breadth of ray just beyond base, 9 mm.; rays sharply constricted at base, arched, gradually tapered to a blunt point; disk small, slightly convex; ray uniformly beset with delicate, slender, tapered spinelets surrounded by a relatively very broad ruff of small crossed pedicellariae carried on the expanded summit of a retractile sheath which covers all but the tip of spinelet; spinelets and sheaths on disk smaller than those of rays; serial arrangement not very evident except on sides of ray; actinal plates in 0 to 2 incomplete series; adambulacral spines two, the inner with a group of pedicellariae, the outer only sporadically; only one pair of postoral adambulacrals in contact; crossed pedicellariae very small, with an unusually broad denticulate terminal lip; straight pedicellariae small, ovate, or lanceolate, compressed.

Description.—Rays abactinally well rounded, and disk sometimes slightly higher than base of rays. Spines very delicate, slender, tapered, terete, bluntly pointed, rather widely spaced, each invested by a thick, distally widely expanded, sheath the convex distal surface of which bears very many crowded, small, crossed pedicellariae of characteristic form. These sheaths usually cover all but the tip of the spine, and sometimes extend beyond the tip. In alcoholic specimens the expanded terminal portion is subcircular or irregular in outline as viewed from the end of the spine, 1 to 1.5 mm. broad, and resembles a furry ruff or stole. The spines are all very similar, the abactinal being a little shorter than the marginal and in less evident longiseries. Regular serial arrangement is theoretically present owing to the arrangement of the plates, but some of the carinals, dorsolaterals, and superomarginals carry two spines, or even three, in the transverse series on the plate. As shown in Plate 18, Figure 5, this breaks up the regularity of the longiseries of spines. The space between the spines varies greatly. Sometimes the stoles nearly touch; sometimes they are widely spaced. In gravid specimens there is usually a broad naked area on either side of the carinal series (which, in such cases, is likely to be fairly regular). The abactinal spines (which are roughened on the distal portion) are 1.5 to 1.8 mm. long.

The skeleton (pl. 13, fig. 1) is characterized by a partial degeneration of some of the abactinal connectives, by which the carinal plates are more or less (and irregularly) isolated. There is a carinal, a dorsolateral, 2 marginal, and 0 to 2 incomplete series of actinal plates as shown in the drawing, where also the position of the isolated rather inconspicuous papulae are indicated. There is evidently started in this species a process similar to that which took place in the ancestors of such diverse genera as *Lysasterias, Adelasterias, Pycnopodia, Rathbunaster.* Degeneration of the abactinal skeleton is characteristic of very cold water forms, and particularly those of the antarctic.

The inferomarginal plates carry a single spine with a complete and large ruff of pedicellariae. In some specimens a majority of the superomarginal plates also carry but one spine; proximally, however, there are usually two or three. The actinal spines are rather small and do not occur in any except the largest specimens (R 30 mm.).

Adambulacral plates regularly with two slender subequal spines about 1.5 mm. long. Most of the outer spines of the proximal half of ray (and sporadically those of distal half) bear at mid height a thick cluster or pad (sometimes a complete wreath) of very small crossed pedicellariae similar to those of the other spines, while a few of the inner spines carry sporadically a smaller cluster. The first plate is longer than those following and is in contact with its fellow along two-thirds or three-fourths of the interradial margin, the outer portion of this margin being generally free. This pair of plates is monacanthid and constitutes all there is of an adoral carina, the second pair being widely separated interradially. A young specimen from Kyska with R 6 mm. has the first pair of adambulacrals separated interradially.

Mouth plates rather narrow, each with two spines, an inner slender, blunt actinostomial as long as, or a little shorter than the median suture and a longer suboral similar to the first adambulacrals. This spine rarely carries a group of small lanceolate straight pedicellariae.

Crossed pedicellariae small (0.125 to 0.135 mm. long), with very broad terminal denticulated lip. (Pl. 13, figs. 5, *5a–5c*.) They form a thick mat on the expanded convex terminal portions of the circumspinal sheaths, upward of 8 to 10 occurring along the radius, from spine to periphery; and they form smaller clusters on the adambulacral spines, as detailed above.

Straight pedicellariae small, broadly lanceolate to ovate truncate, with narrow jaws. The abactinal and lateral, scattered on the integument measure 0.25 to 0.37 mm. long (pl. 13, figs. 6, 6*a*. 6*b*). Actinal pedicellariae are lanceolate with the tips of jaws curved, sharp, and crossed; similar smaller ones occur in groups on the furrow face of the adambulacrals and at base of inner oral spine (fig. 6*c*).

Madreporic body small, with few coarse striae, situated near margin of disk.

Color in fresh alcohol whitish, or yellowish white.

Tube feet in four series, rather crowded; the pores are broadly lanceolate, not very crowded.

Gonads very large in male; numerous lobulated divisions arise pinnately from the axis which extends sometimes nearly to the end of ray, the longer divisions being on the mesial side. The gonads are attached to the body-wall just above and between first and second inferomarginals (pl. 13, fig. 1, *g*), the duct passing downward to open on a papilla just exterior to the fourth adambulacral plate. The two papillae stand close together at the actinal end of the axillary channel. (Pl. 13, fig. 3, *g*.)

Type.—Cat. No. E. 1504, U.S.N.M.

Type locality.—Station 3322, north coast of Unalaska, Aleutian Islands, 53° 28′ 45″ N., 167° 23′ 50″ W., 35 fathoms, black sand, bottom temperature 42.4° F., three specimens.

Distribution.—Bering Sea, in the vicinity of the Aleutian Islands; from Unalaska to Kyska, 43 to 59 fathoms (depth at Kyska not recorded).

Specimens examined.—In addition to the types, 12 specimens:

Station 3319, north coast of Unalaska, 53° 40′ 30″ N., 167° 30′ W., 59 fathoms, black sand, bottom temperature 40.8° F., six specimens.

Station 3321, vicinity type locality, 54 fathoms, dark mud, bottom temperature 41.5° F., three specimens.

Station 4777, Petrel Bank, Bering Sea, off Semisopochnoi Island, 52 to 43 fathoms, fine gravel, one specimen.

Kyska Island (Kyska Harbor), Aleutian Islands (177° 30′ E.), W. H. Dall (189–1015; 188–1014; 173), two specimens.

Genus STENASTERIAS Verrill

Stenasterias Verrill, Shallow-water Starfishes, 1914, p. 145.—Type, *Asterias macropora* Verrill.—Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 12, 1923, p. 598.

Diagnosis.—Rays six, slender. Differing from *Leptasterias* in having unusually large triangular ambulacral pores separated by thin plates. Skeleton very compact, the plates closely imbricated, in longiseries, with very small intervals; marginal plates wide; actinals small, a short second series present; plates closely covered with clusters of minute spinules; adambulacrals diplacanthid; reproduction unknown.

Remarks.—I have not seen a specimen of this small sea star. Verrill's types have disappeared. It is probable that his specimens were all young. The following account is rearranged from the original description.

STENASTERIAS MACROPORA (Verrill)

Asterias (*Leptasterias*) *macropora* Verrill, Amer. Journ. Sci., vol. 28, 1909, p. 65, fig. 10, p. 64. (Rays said to be five!)

Stenasterias macropora Verrill, Shallow-water Starfishes, 1914, p. 145, pl. 50, fig. 7; pl. 74 fig. 4; pl. 84, figs. 5–5*i*.

Description.—Disk small; rays six, slender constricted at base, convex, with median row of more prominent ossicles. R 15 mm., r 3 mm., R 5 r. Ambulacral furrow unusually wide and open; tube feet and pores unusually large, the pores triangular, overlapping by their acute angles and separated only by thin plates.

Abactinal plates rather closely imbricated, the spaces between being very few and small, with only one or two papulae; carinal plates thicker and larger, subtriangular, with acute cusps and concave edges. These overlap the plates proximal to them. Dorsolaterals in three longiseries, proximally, then two, subquadrate and subtriangular in outline. (Verrill, 1914, pl. 84, fig. 5*h*.) Dorsal spinelets numerous, small, short, stumpy, usually truncate or slightly clavate, but not much enlarged at tip and not much longer than thick; in small groups on the larger plates, isolated on the smaller ones.

Inferomarginal plates[25] rhombic, imbricated, overlapping the outer actinals, bearing usually two or three small tapered spines, like the actinals; two series of very small actinal papular spaces.

A single row of somewhat quadrate, overlapping, actinal plates which bear one or two small, rather stout, tapered spines; a series of small oblong connective ossicles between these and the adambulacral plates, on the basal part of ray, each of which may also bear a spine.

Adambulacral plates strong, unusually thick radially, mostly diplacanthid; spinelets long, slender, tapered, acute or subacute, carry a few small compressed lanceolate straight pedicellariae.

Straight pedicellariae compressed, acute, lanceolate, of rather large size but few in number are present in actinal interradial region, and similar smaller ones along the edges of the ambulacral grooves. Crossed pedicellariae "few and minute."

"The specimens of this species are small and poorly preserved, having lost many of their spines. It appears to be allied to *L. aequalis* more nearly than to other species, but it is much more slender than that and has much larger ambulacral pores, while the dorsal plates are closely imbricated.

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[25] The description is confused. The author says that the marginal plates next to the "peractinals" (hence the inferomarginal series) runs along the under side of the rays, but "*curves upward to the dorsal side at the disk.*" This is most unusual behavior for inferomarginal plates and if true is peculiar to *Stenasterias.* I suspect however that superomarginals were confused with inferomarginals at base of ray.

"Sitka (Harriman expedition); Queen Charlotte Islands (G. M. Dawson)."

Remarks.—Unfortunately the specimens of this species have disappeared, so that nothing can be added to the original description. In the first notice of the species the rays are described as five, which is probably a typographical error, as nowhere in the definitive account is any such variation indicated.

Genus EVASTERIAS Verrill

Evasterias VERRILL, Shallow-water Starfishes, etc., 1914, pp. 51, 151. Type, *Asterias troschelii* Stimpson.—FISHER, Ann. and Mag. Nat. Hist., ser. 9, vol. 12, p. 599.

Diagnosis.—*Asteriinae* differing from *Asterias* in having numerous actinal plates (each bearing one or two spines) arranged in from three to six longiseries which alternate with longiseries of large actinal papulae; inferomarginal plates lateral rather than actinal in position. Abactinal skeleton irregularly reticulate, usually robust, but composed of small irregular plates (the primaries three or four lobed, the secondaries variously irregularly elliptical or elongate); spines short, stout and slender mixed, or slender only, or robust only, terete, tapered, conical, or subglobose; adambulacral plates small, diplacanthid, or irregularly diplacanthid and triplacanthid, the spines carrying prominent clusters of crossed and straight pedicellariae; adoral carina composed of three to five pairs of adambulacrals; gonads open dorsally, on the disk, close to the interradial lines.

Remarks.—This genus, so far as known, is confined to the intertidal zone and shallow water of the north Pacific from the Okhotsk Sea to central California. It is most abundant from southern Alaska to Puget Sound, where in great inlets it vies for dominance with *Pisaster ochraceus.*

In fact it bears considerable superficial resemblance to *Pisaster*, especially to the numerous varieties of *P. ochraceus.* I have seen short-rayed examples of *Evasterias troschelii* forma *alveolata* which might easily be mistaken for slender-rayed *Pisaster ochraceus* forma *ochraceus.* The resemblance concerns the dorsal spinulation and the multiple longiseries of actinal plates. *Pisaster*, however, almost always has rays which are broader at the base and evenly tapered; monacanthid adambulacral plates; no pedicellariae on the adambulacral spines; much more sunken actinostome; very characteristic furcate straight pedicellariae.

The modifications and distribution of the abactinal spines exhibit curious analogies in the two genera. Corresponding forms are indicated in the following list.

Pisaster giganteus.	*Evasterias echinosoma.*
P. ochraceus f. *ochraceus.*	*Ev. troschelii* f. *alveolata.*
P. ochraceus f. *confertus.*	*Ev. troschelii* f. *acanthostoma.*
P. ochraceus f. *nodiferus.*	*Ev. troschelii* f. *troschelii.*

EVASTERIAS TROSCHELII (Stimpson)

? *Asterias epichlora* BRANDT, Prodromus, 1835, p. 270.

Asterias epichlora STIMPSON (part), Bost. Journ. Nat. Hist., vol. 6, 1857, p. 528.

Asterias troschelii STIMPSON, Proc. Boston Soc. Nat. Hist., vol. 8, 1862, p. 267.—PERRIER, Révision des Stellérides, 1875, p. 71.—BELL, Proc. Zool. Soc. London, 1881, pp. 495, 505.—WHITEAVES, Trans. Roy. Soc. Canada, vol. 4, 1887, p. 116.

Asterias brachiata Perrier, not Linnaeus, Révision des Stellérides, 1875, p. 65; Gulf of Georgia.

Asterias (*Diplasterias*) *epichlora* de Loriol, Mém. Soc. Phys. et d'Hist. Nat. Genève, vol. 32, 1897, p. 19, pl. 3, figs. 2, 2*d*.

Asterias saanichensis de Loriol, Mém. Soc. Phys. et d'Hist. Nat. Genève, vol. 321, p. 897, p. 23, pl. 2, figs. 3, 3*a*–3*d*, 4, 5. Saanich Inlet, Vancouver Island.

Asterias victoriana Verrill, Amer. Journ. Sci., vol. 28, 1909, p. 68; Victoria, British Columbia. Shallow-water Starfishes, 1914, p. 124, pl. 53, fig. 1; pl. 54, figs. 1, 2; pl. 69, fig. 4; pl. 82, figs. 1–1*c*.

A. troschelii (St.) var. *rudis* Verrill, Amer. Nat., vol. 43, 1909, p. 542; Victoria, British Columbia.

Asterias acanthostoma Verrill, Amer. Nat., vol. 43, 1909, p. 543; no locality.

Leptasterias macouni Verrill, Shallow-water Starfishes, 1914, p. 124; Departure Bay, British Columbia.

Leptasterias (?) *inequalis* Verrill, Shallow-water Starfishes, 1914, p. 117, pl. 73, fig. 2; text, figs. 4, 5 (probably very young specimen, Orca, Prince William Sound).

Leptasterias epichlora miliaris var. *subnodulosa* Verrill, Shallow-water Starfishes, 1914, p. 139; Wrangell, Alaska.

Evasterias troschelii Verrill, Shallow-water Starfishes, 1914, p. 151, pl. 22, figs. 1, 2; pl. 25, figs. 1, 2 (type); pl. 26, figs. 1, 2; pl. 62, fig. 1; pl. 106, figs. 1, 2.

Evasterias troschelii var. *rudis* Verrill, Shallow-water Starfishes, 1914, p. 158.

Evasterias troschelii var. *densa* Verrill, Shallow-water Starfishes, 1914, p. 161; Victoria, British Columbia.

Evasterias troschelii var. *alveolata* Verrill, Shallow-water Starfishes, 1914, p. 162, pl. 62, fig. 1; Departure Bay, British Columbia.

Evasterias troschelii var. *subnodosa* Verrill, Shallow-water-Starfishes, 1914, p. 163; Wrangell, Alaska.

Evasterias troschelii var. *parvispina* Verrill, Shallow-water Starfishes, 1914, p. 163, pl. 106, figs. 1, 2; Sitka, Alaska.

Evasterias acanthostoma Verrill, Shallow-water Starfishes, 1914, p. 165, pl. 20, figs. 1, 2; pl. 24, fig. 3 (type); Popof Island, Alaska.

Diagnosis.—Rays five, rarely six; actinal plates in three, sometimes four series at base of ray; superomarginal plates lateral in position, defining ambitus; adambulacral armature diplacanthid, or diplacanthid and monacanthid. Abactinal spines exceedingly variable: (1) Large and much smaller ones intermingled without the formation of a reticulate pattern (forma *troschelii*, pl. 60, fig. 1); (2) large and much smaller spines, grading imperceptibly into uniformly coarse spines, but arranged in reticulate pattern (forma *alveolata*, pl. 62); (3) spines uniformly very small and arranged usually in a reticulate pattern (forma *acanthostoma*, pl. 64, figs. 2, 3; pl. 65). Rays generally long and fairly slender, but very variable. Straight pedicellariae, small lanceolate, without terminal teeth.

Evasterias troschelii is one of the most variable among many variable species of the northwest coast. Its forms very closely parallel those of *Pisaster ochraceus* and many specimens when preserved resemble slender rayed examples of that species. Forma *acanthostoma* parallels forma *confertus* of *Pisaster ochraceus;* forma *alveolata* resembles forma *ochraceus;* while forma *troschelii* and its acervate intergrades with *alveolata* correspond to forma *nodiferus* (of *P. ochraceus*).

It is not possible to identify with certainty Brandt's *Asterias epichlora*, from Sitka, although in all probability the green phase of forma *alveolata* was referred to. Brandt's description is as follows: Diameter of the moderate sized subdepressed disk scarcely exceeding a thumb-breadth. Rays five, conical, unequal, subdepressed, about three thumb-breadths in length (i. e., R=6 r). Dorsal surface dull green, covered with crowded white spines, of which the summit is capitate, arranged in a reticulate pattern. Lower surface pale flesh color.

Professor Verrill applied *epichlora* to the commoner 6-rayed *Leptasterias* of the intertidal zone of the southern Alaskan coast (two species). I have seen but one 5-rayed example of these species among several hundred examined; and if we adopt an inch as a thumb breadth, the size given by Brandt does not conform to the size or proportions of the *Leptasterias*. The proportions, inequality of rays, their slightly depressed form, and color of Brandt's species agree fairly well with small examples of *Evasterias* which I collected at Departure Bay, British Columbia. However, in order to avoid a great deal of confusion which would follow a shift of the name to *Evasterias*, *epichlora* had best be consigned to the limbo of disused names. It is certainly misapplied in connection with any 6-rayed *Leptasterias*.

The variations are so numerous and confusing in *Evasterias troschelii* that no attempt will be made to describe the species. Rather the chief formae will be analyzed as well as the material permits.

Forma TROSCHELII (Stimpson)

Plate 58, Figures 1, 1*a*, 4, 6, 6*a*; Plate 59, Figures 3, 3*a*; Plate 60; Plate 61, Figure 1; Plate 64 Figure 1

Asterias troschelii Stimpson, 1862, p. 267.
Asterias victoriana Verrill, 1909, p. 68; 1914, p. 102.
Leptasterias macouni Verrill, 1914, p. 124.
Evasterias troschelii var. *rudis* Verrill, 1914, p. 158.
Evasterias troschelii var. *subnodosa* Verrill, 1914, p. 163.

This is the forma to which the type of the species belongs. Plate 60, Figure 1, is an extreme having widely spaced and rather slender major spines, and unusually few minor spinelets. Figure 2 is a stouter-rayed specimen having robust subtruncate tubercular major spines. The minor spines are in lines here and there outlining poorly defined areas. Plate 64, Figure 1, is a slenderer-rayed specimen in which the minor spines have increased in number and it is intermediate with forma *alveolata* having both coarse and slender spines, as Plate 62. When full grown, fat-rayed specimens of *troschelii* have the spines rather widely spaced, as in Plate 61, Figure 1. This is Verrill's variety *rudis*—simply a growth stage.

The type forma is extremely variable and it is practically impossible to find two specimens alike. There are slender and stout rayed examples. The major spines are well spaced, or they may be clustered in twos and threes, or may form subnodular prominences. The major spines are relatively slender or are very thick, truncate, and many times the diameter of the minor spinules. The latter are few and irregularly scattered between the major spines; or they may suggest a very poorly defined reticulum.

The salient feature of this forma is the wide disparity in size between the major and minor dorsal spines which do not form a meshwork design. Stimpson says:

> The large ones are few in number, shorter but much thicker than the ventrals, capitate, with flattened heads, and are arranged in a pretty regular though somewhat zigzag median row of about

25 spines, crowded near the disk, but further apart near the extremity of the ray. Between this row and the marginal row there are scattered a few more of the larger kind, sometimes in clusters or short rows of three or four. On the disk they form a more or less distinct pentagon, within which there is another circle and a spine of large size in the center. The spines of the smaller kind, minute, slender, and truncated, are scattered between the large ones. (Stimpson; see pl. 60, fig. 4, type.)

The large spines are striated at the summit, and in large specimens the smaller sort are also pretty definitely grooved. The smaller spines sometimes form transverse rows, but they do not define the papular areas, or complete the reticulation as in *alveolata*, and intermediates. Four small specimens from near Tacoma have the larger spines abnormally magnified and the smaller all but absent, while one from Orca, Prince William Sound, Alaska, with R 65 mm., has the larger spines distinctly acervate.

The superomarginal spines are slenderer than the larger abactinal, usually tapered and blunt, and form a very regular series which curves up at the interradius to the level of the madreporite. While the spines are generally single, sometimes a small spinelet accompanies the larger. In giant specimens the principal spine is often subcapitate, truncate, and striate.

The inferomarginal spines (usually two to a plate proximally) are a little longer and slenderer, pointed, blunt, or subtruncate, varying individually. In giant specimens there are usually two spines to a plate. The intermarginal channel is definite and well defined.

Actinal plates in four series in very large specimens; in three series, in medium-sized; and in two series in small specimens (R 20 mm.). In giant specimens they generally carry two spines in an oblique row, except for the plates of the short inner series which are monacanthid. In medium-sized examples there is usually one spine to a plate; or three rows of actinal spines at the base of ray, then two, and finally one on the outer half or third of the ray. But in giant specimens, where the plates are diplacanthid there may be seven rows of actinal spines at the very base of the ray, although the duplicate series of each range of plates is evident enough by rather wide channels between the longitudinal rows of plates. The submarginal channel is nearly as broad as the intermarginal channel. The spines are similar to the inferomarginals and are variously cylindrical, tapered, or swollen, with blunt-terete or blunt-compressed, or obliquely dressed extremities; or the whole spine is a trifle curved upward. In very large examples the spines are shallowly grooved at the tips. The spines are slenderer and longer than the larger abactinal spines, but in medium-sized examples may be subequal in caliber.

The adambulacral armature is alternately one and two spines to a plate, with one on the first five or six (adoral) plates, and two on a variable number (usually relatively few) of succeeding proximal plates. The spines are slender, tapered, blunt, the furrow spine, as is usually the case, being the slenderer. Near the mouth the spines become longer and slenderer forming a dense chevaux-de-frise over the actinostome. In a giant example, R 270 mm., the adoral adambulacral spines are 8 mm. long (or subtend the arc of the first eight adambulacral plates). At one-fourth R, measured from the mouth, the spines are 5 or 5.5 mm. long. Medium-sized specimens have two, giant specimens three (or four) adoral pairs of plates in contact interradially.

Mouth plates relatively small, with two unequal, apical and one longer, slender, tapered suboral spine. As the animal grows larger, the actinostome becomes more sunken and the mouth plates relatively inconspicuous. The tube feet are crowded about the mouth, and the entrance to the furrow is only about as wide as the breadth of the combined mouth plates. It widens rapidly, reaching the maximum width at the sixth or seventh adambulacral plate.

The papular areas vary enormously with size of specimen. In giant examples the whole abactinal surface as well as the lateral and actinal channels are a mass of small papulae closely packed in larger areas (with narrow skeletal trabeculae separating them). In medium-sized examples the papulae are also numerous, but the areas are relatively smaller, though closely placed.

Straight pedicellariae (pl. 58, fig. 4) inconspicuous, compressed, broadly lanceolate, largest in lateral and actinal channels; absent or few on dorsal surface. They occur on the oral and adambulacral spines, and not very numerously on the furrow face of the adambulacral plates; length 0.5 to 0.8 mm.

Crossed pedicellariae (pl. 58, figs. 1, 1*a*) very numerous around the spines, among the papulae, and on the surface of the plates between the areas, where they have well-developed peduncles. Spine wreaths on big specimens very thick. They are complete on the abactinal and both series of marginal spines; on actinal and adambulacral spines the pedicellariae are in clusters. Abactinal pedicellariae 0.27 to 0.28 mm. long. Larger actinal and adambulacral pedicellariae, 0.31 to 0.36 mm. long.

Color in life, variable. A small specimen from Departure Bay, British Columbia, gray green. A medium-sized specimen, general tint plumbeous, the papular areas reddish brown; actinal surface flesh color.

Madreporic body prominent, slightly convex, with fine, intricate striae situated about mid r.

Young.—Very small specimens resemble coarse-spined *Leptasterias*. The smallest example (Orcas, San Juan Islands, Wash.) has R only 9 mm., but there is already a series of actinal plates and spines. The young are rather easily recognized as they have the peculiarities of the adult, even greater discrepancy in size between the two sorts of spines. The larger spines are capitate, striate, subtruncate, and form a very definite carinal series, with a few scattered dorsolaterals. There is a regular series of superomarginals, of inferomarginals, and of actinals, the latter not extending the entire length of the ray.

Type and type locality.—That of species.

Remarks.—Although only the distal part of a ray of Stimpson's type remains (No. 1306, U.S.N.M., pl. 60 fig. 4), it is unmistakable. It closely resembles Plate 60, Figure 1, which may be considered, therefore, as representing typical *troschelii*. Verrill's interpretation of *troschelii*, as represented by his Plate 26, is consequently not correct.

Verrill's *Asterias victoriana* (1914, p. 102, pl. 53, fig. 1) is a somewhat distorted specimen of forma *troschelii*, having few minor spines. It resembles Plate 60, Figure 2 (San Juan Islands, Wash.) but has slightly slenderer primary dorsal spines. No. 603, Stanford collection, Insect Island, British Columbia, is nearly identical with the type of *victoriana*.

Verrill's variety *rudis*, the type of which I have seen, is a giant form of *troschelii* resembling Plate 61, Figure 1. His variety *subnodosa* (type from Wrangell, Alaska) is a variant of forma *troschelii*, with large primary spines somewhat acervate in places. It is one of the narrow rayed varieties between forma *troschelii* and the variety of *alveolata* in which the alveolations are breaking up and primary spines are differentiating as in Plate 62, Figure 1. I have examined the types of these two varieties in the Yale Museum.

I have examined the type of *Leptasterias macouni* Verrill which was taken at Departure Bay, British Columbia, and is now in the Ottawa Museum. It is, I think, a 6-rayed, young, *Evasterias troschelii* probably forma *troschelii*. The radii are 41 mm. and 5 mm. The outstanding feature of this specimen is the presence of four series of actinal plates (unheard of in a small *Leptasterias*) and the behavior of the superomarginals, the series of which curves up strongly at the interbrachium. The intermarginal channel is narrow and does not widen at the base. The first series of actinals extends nearly to the tip of ray (within a few inferomarginals of the tip); second row about three-fourths the length; third row, which is quite compressed about half the length; there are four or five compressed plates of a fourth row at base of ray (one or two of them have a tiny spinelet). Superomarginals mostly with one spine, occasionally with a shorter fellow; proximal inferomarginals with two, distal with one; first series of actinals proximally with one or two, distally with one; other actinals with one spine. Adambulacral spines, slenderer than the actinals, alternate two and one; on the diplacanthid plates the inner spine is advanced somewhat into the furrow. The primary abactinal spines are mostly short, thick, and stumpy, somewhat variable in size, while the relatively few minor spines are shorter and much slenderer. Most of the carinal plates have one or two stubby major spines and about two minors while the dorsolaterals have usually one major and about two, quite slender, minors.

Six-rayed examples of *Evasterias troschelii* are rare. I have one with R 72 mm. from Departure Bay, British Columbia. It is close to the particular variation shown by Plate 60, Figure 1, but the rays are relatively short (R = 4.5 r).

The largest specimen which I have examined (station 4222) has R 355 mm., r 46 mm., br. 58 mm.

Forma ALVEOLATA Verrill, emended

Plate 58, Figures 2, 2*a*–2*c*, 5, 7, 7*a*, 7*b;* Plate 59, Figures 1, 1*a;* Plate 61, Figures 2, 3; Plates 62, 63; Plate 66, Figure 1

? *Asterias epichlora* Brandt, 1835.
Asterias epichlora Stimpson, 1857, p. 528.—De Loriol, 1897, p. 19.
Asterias brachiata Perrier, 1875, p. 65.
Evasterias troschelii "typical form" Verrill, 1914, p. 153, pl. 26, figs. 1 and 2.
Evasterias troschelii var. *alveolata* Verrill, 1914, p. 162, pl. 62, fig. 1.
Evasterias troschelii var. *parvispina* Verrill, 1914, p. 163, pl. 106, figs. 1, 2.

Forma *alveolata* is far from being homogeneous. It is a convenient pigeon hole for a large number of small varieties which differ from typical *troschelii* in having the abactinal spines, which are coarser than in *acanthostoma*, arranged in a reticulate pattern. The spines are typically more numerous than in *troschelii;* and when the spines are unequal in size, the smaller are much more numerous than in *troschelii*.

Size medium to large, but I have seen no giants. Largest specimen R 205 mm., r 27 mm. br. 34 mm.

It is not possible to describe this forma with any degree of precision. The principal variants will be indicated by means of figures.

(I) In its most generalized phase this forma may be described as a corase-spined *acanthostoma*, the spines being short, subequal, and defining a reticulum. (Pl. 63, fig. 1.) This variation intergrades with *acanthostoma;* there are slender and thick-rayed specimens and considerable range in the number and caliber of the spinelets. Clayoquat Sound, Departure Bay, Gabriola Inlet, British Columbia; Straits of Fuca, San Juan Islands, Wash.; Monterey Bay, Calif.

(II) The spines increase greatly in number and become fairly packed on the carinal and dorsolateral plates, the papular areas becoming smaller. (Pl. 63, figs. 2, 3.) These multispined forms intergrade with I; and a similar variation in *acanthostoma* differs only in having smaller spines and usually more numerous superomarginal spines. Fort Rupert and Departure Bay, British Columbia; Tongass, Alaska; Monterey Bay, Calif.

(III) Disparity in the size of the spines gradually increases from a slight difference as in plate 62, figure 4, through a series: Plate 61, figure 2; plate 62, figure 2, 3; plate 61, figure 3 and plate 60, figure 3, which have the spines as unequal as forma *troschelii*. Plate 60, figure 3, may be classed as an aberrant *troschelii*, or as an intergrade. Unalaska to Puget Sound.

(IV) Acervation of the major dorsal spines is developed in various degrees—slight to very prominent (pl. 62, figs. 1, 3; pl. 63, fig. 3). Departure Bay and Bayne Sound, British Columbia; Puget Sound.

Each of the above varies as to length and breadth of ray; that is, each variety has longer and shorter as well as slenderer and thicker rayed representatives. I intergrades with II, III, and IV; II and IV intergrade; III and IV intergrade.

In forma *alveolata* the abactinal spines are individually very similar to those of forma *troschelii*. They vary from cylindrical truncate, through clavate forms, to capitate, a little higher than broad to broader than high; and from capitate to a curious flaring obconic form with a convex summit broader than the height. (Puget Sound, Departure Bay, pl. 62, fig. 2.) The summit of the spines is finely striate. The smaller spines, also striate, are cylindrical to clavate, obtuse to truncate, with a certain number slightly tapered and bluntly pointed. When there is disparity in the size of the dorsal spines the smaller are usually more numerous, stand in straight or zigzag single file on the trabeculae and outline the skeletal intervals. The heavier spines form a pretty definite carinal series either singly or in groups, and dorsolaterally occupy (singly or in groups of three to five) the principal nodal points of the skeleton. From the formation of groups (pl. 62, fig. 4) it is only a step to an acervate condition (IV, above).

Specimens from Unalaska have characteristically few major spines but numerous much smaller minor spines. (Pl. 61, fig. 2; pl. 62, fig. 3.) These resemble forma *acanthostoma* with a few heavy spines sprinkled over the surface, but the superomarginals are mostly monacanthid. They differ from *troschelii* in their more numerous secondary spines which have a reticulate arrangement.

The superomarginal spines are similar to those of forma *troschelii*, but often not so regular. They partake of the character of the abactinal spines, varying in robustness, but falling behind the abactinal spines in thickness. They vary from cylindrical to capitate, truncate, the tip being striated, and sometimes asymmetrical and oblique. Spines are usually single, but often accompanied by one or two, much smaller, slender, slightly tapered. Very much less commonly there are two or three subequal spines, but the specimens are not typical in other ways.

The inferomarginal spines are slenderer and longer than the superomarginals, more or less clavate and bent, one or less often two to a plate. Proximally there are three series of actinal plates, with three series of spines. In some specimens many of the actinals are diplacanthid, so that the armature is crowded. I have not been able to find any distinctive difference in the inferomarginal or actinal spines, since the individual and age variations are very confusing. The third or inner actinal row of plates is short as a rule.

Adambulacral spines very similar to those of *troschelii*, generally alternating one and two to a plate, with two on a few plates following the adoral carina. They are typically slender, subterete, blunt (or slightly tapered in the case of the alternate furrow spine). In some heavy-spined examples they are narrowly spatulate, with a shallow groove at end. Adoral carina composed of three to six contiguous pairs of adambulacral plates in specimens with R 120 to 150 mm.; in specimens having R 60 to 70 mm. there are usually three pairs in contact. The broader rayed examples appear to have the fewer number in contact.

Actinostome very small, mouth plates closely similar to those of *troschelii*, having two unequal apical spines and a longer, slender suboral.

Papulae very abundant, completely filling the spaces between spines and masking the small ones in alcoholic specimens.

Crossed pedicellariae (pl. 58, figs. 2, 2*a*–2*c*) vary somewhat in minor details and increase slightly in size in specimens from Unalaska. Monterey specimen; length, 0.225 to 0.24 mm.; Puget Sound, 0.23 to 0.24 mm.; Unalaska, 0.31 to 0.34 mm.—all abactinal. The actinal and adambulacral are somewhat larger.

Straight pedicellariae (pl. 58, fig. 5) of small size and lanceolate in form, similar to those of typical *troschelii*, are fairly abundant in most specimens in the intermarginal, interbrachial, and actinal channels, along the furrow face of the adambulacral plates, and on the adambulacral spines; absent or very scarce on abactinal surface.

Color in life very variable. Notes made at Departure Bay, British Columbia. Red phase: (*a*) Clear flame scarlet, the spines and a very narrow surrounding zone, pale cream color. (*b*) Vermilion, spines Saturn red to orange; or orange vermilion above, larger spines and collars of pedicellariae, white. (*c*) Chinese orange, spines yellowish white. (*d*) Brick red (Indian red), spines whitish. (*e*) Dragon's blood red.

Brownish phase: (*a*) Yellowish dark russet, spines paler. (*b*) Russet to burnt umber; disk mottled with wood brown; spines whitish; skin flecked with pale Nile blue. (*c*) Papulae deep ferruginous; spines whitish with basal zone of bluish gray. (*d*) Mottled rich brown and gray; spines pale blue gray. These are pretty generally pale clay color or faded yellow below.

Green phase: (*a*) Arms banded dark sage green and bright olive; spines cream color. (*b*) Arms olive green, groups of spines cream color, yellowish about their bases. (*c*) Dark sage green without bands, spines whitish (also young with spines pale sage green). (*d*) Major spines acervate—mottled olive green and cream color (specimen similar to pl. 63, fig. 3). (*e*) Cream color, papular areas apple-leaf green (specimen like pl. 63, fig. 2).

A specimen of the green phase may have been the type of Brandt's *Asterias epichlora.*

Anatomical notes.—Abactinal plates: There is considerable individual and age variation. The abactinal reticulum is, of course, always irregular. The carinal plates are four lobed and overlap over a third of their length, forming a zigzag or irregular series. In *alveolata* there is one large spine and one to four small ones on each carinal, but in *troschelii* the large spine is often without an accessory. Dorsolateral plates of rather unequal size, irregular in shape, sometimes subtriangular and connected by secondary ossicles also irregular as to size and shape. Marginal and actinal plates closely imbricated, decreasing in size from the superomarginal to the inner actinals. The plates are arcuately lozenge shaped to four lobed, the dorsal lobe the longest. In the case of the actinals and inferomarginals it strongly underlaps the descending lobe of the plate, just above. There are basically three series of actinals, with a short fourth series in very large examples, in contrast to the six (or seven) of *E. echinosoma.*

The actinostomial ring (pl. 59, fig. 1) is small, the actinostome being about as broad as the length of the first 10 ambulacral ossicles (or the first pair plus nine). The median suture between the two halves of the first enlarged pair is serrate and the length of the dorsal crest is that of the next six plates—a very common proportion in the Asteriidae. The odontophore has a characteristic form reminding one of the valve of a small chiton shell. The interbrachial septum is small owing to the small size of the disk. There is a pillar of plates extending upward from the odontophore, and between this and where the true arm plates end at the interbrachial angle there is an uncalcified membranous septum in medium-sized specimens. In the giant examples the whole septum appears to be filled with plates, and in these specimens the rather triangluar entrance from the disk coelom to that of the arm is surprisingly small and filled by a much folded lobe of the ventral stomach.

The gonads open dorsally, close to the interradial line, about one-third r from the margin; and in general form are elongate fusiform with numerous fusiform lobes on the mesial side, these being subdivided into short globular lobules. The intestinal coecum is tripartite; the stomach is rather crowded in the small disk, and the hepatic coeca are large and extend nearly to the end of the long rays. No Polian Vesicles.

Type locality of forma alveolata.—Departure Bay, British Columbia.

Remarks.—This forma corresponds to Dr. William Stimpson's *Asterias epichlora,* as several specimens labeled by him are in the collection of the United States National Museum. He considered *Asterias troschelii* to be a distinct species.

I think Doctor Stimpson's identification of Brandt's *epichlora* is correct; green specimens are not uncommon. It would lead to endless confusion to adopt *epi-*

chlora, however, since Professor Verrill has used the name for the common 6-rayed *Leptasterias* of the Alaskan coast, in spite of the fact that Brandt wiites that his *epichlora* had five rays.

The name *alveolata* was given by Verrill to a specimen taken at Departure Bay, British Columbia, and now in the Ottawa Museum. It is one of the swollen-rayed variants, such as Plate 62, Figure 2, but with the spines as in Plate 63, Figure 1. The papular areas are sunken, accentuating the skeletal mesh, since the specimen was dried before being properly preserved.

The specimen figured by Verrill (1914, pl. 26, figs. 1 and 2) as typical *troschelii* belongs to forma *alveolata*. It is very similar to Plate 62, Figure 4, and has not the peculiarities of the type of *troschelii*. Verrill's Plate 22 represents a very immature specimen from Juneau, Alaska. It is a young *alveolata* with considerable disparity in size between major and minor abactinal spines. The areolations are not so distinct as in the foregoing specimen. This is characteristic, however, of many young specimens, which pass through a stage in which they resemble forma *troschelii*. The young of *Pisaster ochraceus* usually have acervate dorsal spines. Much fewer adults are so characterized, so that the young are in many cases transiently forma *nodiferus*.

The type of Verrill's variety *parvispina* is a very immature *alveolata* which was taken at Sitka. Its peculiarities are partly due to immaturity. Among examples of *troschelii* and of *alveolata* having two sizes of dorsal spines, certain ones not infrequently have unusually slender minor spines, while the major spines are somewhat less often quite slender.

Forma *alveolata* is therefore much more inclusive than Verrill's variety *alveolata*. This name has been adopted since *Asterias brachiata* Perrier, 1875, is invalidated by *A. brachiata* Linnaeus.

Most of the specimens which I collected or examined at Departure Bay, numbering several hundred, were accompanied by a commensal polynoid annelid, *Halosydna fragilis*, which lives among the tube feet, usually at base of ray, or in the actinostome.

Forma ACANTHOSTOMA (Verrill)

Plate 58, Figures 3, 3*a*, 3*b*; 8, 8*a*–8*c*; Plate 59, Figure 3*b*; Plate 64, Figures 2, 3; Plate 65; Plate 66, Figure 2

Asterias acanthostoma Verrill, 1909, p. 543, footnote.
Evasterias acanthostoma Verrill, 1914, p. 165, pl. 20, figs. 1 and 2; pl. 24, fig. 3.

Plate 64, Figure 3, shows a typical specimen from Unalaska and Plate 66, Figure 2, the actinal surface of the same; Plate 64, Figure 2, is one of the most typical of the Tongass, Alaska, specimens. Plate 65, Figure 1, is a large slender-rayed variant from Orcas Island, San Juan Islands, Wash., and Figure 2 a thick-rayed specimen from Victoria. Plate 65, Figure 3, is an enlargement of a ray of the Unalaska specimen. Plate 63, Figure 2, is a problematical variant from Tongass, Alaska. Although taken with *acanthostoma*, it and other specimens may perhaps be more appropriately classed as very slender spined *alveolata*.

Forma *acanthostoma* intergrades with *alveolata*. It is not possible to place certain specimens definitely in either forma since they stand midway between. Typical specimens differ from forma *alveolata* in having uniformly small abactinal spinelets which stand in single file on the irregular reticulum of the skeleton and divide the abactinal area into areolae, or are more grouped and scattered, so that the reticulation is not so evident; superomarginal spines in combs or groups of three to five; adoral adambulacral spines slightly longer. In mature specimens R = 5 to 7.6 r and 4 to 6.5 br. Largest specimen, R 310 to 330 mm., r 46 mm., R = about 7 r.

The abactinal spines are all small and of nearly uniform size, except near the tip of the ray, where in some but not all specimens they are unequal, the larger doubtless being homologous with the major abactinal spines of *alveolata*. The spinelets are numerous, nearly equal, either tapered or clavate, with rough sulcated tips, and they either stand in single file on the skeletal meshes, very definitely subdividing the dorsal area into rather irregular, numerous areas (the papular areas), or, less often, they do not form any very evident reticulations. In the type specimen: "Most of those on the basal part of the rays stand in short transverse or oblique rows or combs, varying from 2 or 3 to 10 or more, but many stand singly or in small clusters. On the distal third of the rays they become much more crowded and stand in small groups or singly; on the disk they form irregular short rows or imperfect reticulations." (Verrill.) Several specimens from Unalaska and Victoria exhibit this imperfect reticulation but it is only an individual variation. (Pl. 65, figs, 1, 2.) More often the spinelets are arranged in a definite reticulate pattern, in which case the spinelets are more numerous. (Pl. 64, figs, 2, 3.) On the proximal half of ray these reticulations are more or less lengthened transversely, so that the spinelets appear to form transverse combs of variable length, because the transverse trabeculae are much longer than the connecting longitudinal ones. The carinal series may not be distinct or it may be well marked, as in most of the Tongass examples, in which the spinelets stand in several ranks along the radial line.

The superomarginal spines are similar to the dorsals but a little longer and stouter. There are generally three, four, or even five to a plate, in an arcuate vertical comb; or a comb of three, with an extra spine on its adoral side. Distally the combs are reduced to two spines, and near the tip there is usually only one spine. The spines are sometimes subequal; or the fourth and fifth spines, when present, may be smaller; or the median spine of the series may be somewhat enlarged over the others. Intermarginal channel broad in large specimens; in medium sized ones narrower than the superomarginal combs.

Inferomarginal and actinal spines similar in form to those of *alveolata*, rather crowded, and increasing in size from the inferomarginals (which are a little longer than the superomarginals) toward the furrow. Inferomarginal spines are usually two to a plate (sometimes three, and at base of ray one). The spines are clavate, or tapered, obtuse, or bluntly pointed, finely striated at the ends. There are usually three rows of actinal plates at the base of the ray; rather exceptionally four (Verrill mentions five, but I have never found so many in my specimens). Plates of the outer row bear two or three spines in an oblique series; the others generally two; whence the crowded condition of the actinal armature. The spines vary greatly in caliber from a slightly swollen form with a tapered blunt terminal half, to broadly clavate, subtruncate. In the very large specimens the interactinal channels are well marked but tend in others to be obliterated by a crowded armature.

The adambulacral spines stand alternately one and two to a plate, with a variable number of diplacanthid plates following the adoral carina. The spines are similar in form to those of *alveolata*, but a little longer toward the actinostome. This character is not of much practical use, owing to variability and the difficulty of finding a method of comparison. In *acanthostoma* the longest adoral subambulacral spine (of the second, to fourth plate) is about as long as the first eight adambulacral plates measured on the furrow face; and in forma *alveolata* it is about seven plates in length—perhaps 10 to 14 per cent less. In forma *troschelii* the spines are usually still shorter. There are generally five pairs of adoral adambulacral plates joined to form a narrow adoral carina and the actinostome is very contracted, as in *alveolata*.

The oral plates are not appreciably different from those of *alveolata*, there being two (sometimes three) apical, and one suboral spines.

The madreporic body is large, with fine, very irregular, striae; its outer edge is about mid r.

The papulae are very numerous and distributed as in *alveolata;* the abactinal papular areas are often smaller and more numerous, but there is no constant difference.

The straight pedicellariae are similar to those of *troschelii*—lanceolate, blunt or pointed, small—and are similarly distributed.

The crossed pedicellariae are very numerous among the papulae as well as surrounding the spines. They have the distribution characteristic of the genus. The abactinal pedicellariae measure about 0.30 to 0.31 (Unalaska); 0.2 to 0.26 (Tongass); 0.23 to 0.24 (Victoria). In profile the upper part of the outer surface of the jaw is flattened or even slightly depressed. Northern specimens have larger pedicellariae.

Variations.—The principal variations of the type form have already been noted. The abactinal spines vary in robustness as well as in the precise shape. In the largest specimen from Victoria, British Columbia, they are cylindrical or slightly tapered, two or three times as high as thick, blunt or truncate, with a sulcated tip. This is the usual form but a number of spines especially near the end of the ray are thicker and clavate. There is less difference in spine form than in *alveolata*. The differences in the arrangement of the abactinal spines—by which the papular areas are more or less completely fenced in—constitute one of the major variations. There is also a conspicuous difference in the robustness of the rays. The largest specimen from Victoria, British Columbia, with R 310 to 330 mm., and considerably shrunken in drying has the ray 60 to 65 mm. broad at base, or about one-fifth R. The stoutest specimen has the arm breadth about one-fourth R (Unalaska), while another from the same locality has the arm breadth one-fifth to one-sixth R.

Tongass, southeast Alaska, Plate 64, Figure 2. The specimens from this locality have been referred to *acanthostoma*, although they present certain points of difference which at first sight give them a very distinctive appearance.

The rays are very slender and long, R equalling about 6½ br measured at widest part. The rays taper very gradually from this narrow base. The abactinal spines are unusually numerous and are small. They completely surround the papular areas, dividing the abactinal surface into very numerous irregular meshes. The carinal series is pretty well marked at the base of the ray. The spinelets vary in different individuals, being cylindrical or tapering and blunt, and rather slender, or else shorter and thicker, with a more or less broadened, truncate summit. This character is more marked on the median than on the lateral portions of the abactinal area. In forms with well-marked carinal plates there are usually numerous crowded spines on each plate. It is only a short step to the production of such forms as that shown in Plate 63, Figure 2, which can be classed as a small spined *alveolata*. A few specimens from Tongas must be placed in *alveolata* on account of the coarse abactinal spines and the presence of only one or two superomarginal spines. The ordinary Tongass *acanthostoma* have from three or four to six superomarginal spines, of which one is usually larger than the rest.

Certain specimens in the Puget Sound region are similar to the Tongass variety. (Pl. 65, fig. 1, Orcas Island, San Juan Islands.)

Type locality of forma acanthostoma.—Popof Island, Shumagin Islands, Alaska.

Remarks.—The type of Verrill's *acanthostoma* was taken at Popof Island, Alaska, and the forma is best developed in the region between Unalaska and Kodiak. In southern Alaska, British Columbia, and the Puget Sound region it intergrades so frequently with isacanthous forms of *alveolata* that it can be described as a small spined offshoot of the isacanthous varieties of *alveolata* having polyacanthid superomarginals.

A specimen from Departure Bay which has the small pointed abactinal spines of some specimens of *acanthostoma*, but only two superomarginal spines, in life was dark bay color, the spines being Antwerp blue.

Type of Evasterias troschelii.—Cat. No. 1306, U.S.N.M.

Type locality of Evasterias troschelii.—Puget Sound, Wash. (Simeahmoo), northwest boundary survey, Dr. C. B. Kennerly.

Distribution.—St. George Island, Pribilof Islands to Monterey Bay, Calif. Intertidal zone to 39 fathoms.

Specimens examined.—Three hundred and forty-six.

Specimens of Evasterias troschelii examined

Locality	f. troschelii	f. alveolata	f. acanthostoma	Remarks
St. George, Pribilof Islands	6			R 30 mm., young.
Unalaska		8	8	Albatross, 1 intermediate.
Captains Bay, Unalaska	1			W. H. Dall, 1872.
Dutch Harbor, Alaska		1		Stanford Coll.
Mist Harbor, Nagai, Shumagin Islands			4	Albatross, 1893.
Uyak Bay, Kodiak			1	Albatross, 1903, seine.
Kodiak		4		W. J. Fisher.
Orca, Prince William Sound, Alaska	10	19		Stanford Coll.
Sitka, Alaska		1	2	Albatross, 1892.
Naha Bay, Alaska		2		Albatross, 1905.
Tongass, Alaska		5	15	Nichols.
Ward Cove, Revillagigedo Island, Alaska		1	3	T. H. Street.
Forrester Island, Alaska		1		Stanford Coll., H. Heath.
Herendeen Bay, Alaska		6	1	Albatross, 1890.
Freshwater Bay, Alaska	1			Intermediate.
Insect Island, British Columbia	1			Stanford Coll.
Fort Rupert, British Columbia		1		Do.
Boundary Bay, British Columbia	1 juv.	3		Oyster beds; Stanford Coll.
Union Bay, Bayne Sound, British Columbia	12	6	1	Albatross; shore.

Specimens of Evasterias troschelii examined—Continued

Locality	f. *troschelii*	f. *alveolata*	f. *acanthostoma*	Remarks
Taylor Bay, Gabriola Inlet, British Columbia	--------	4	--------	Albatross.
Beaver Harbor, British Columbia	--------	1	--------	Do.
Comox, British Columbia	--------	12	--------	
Departure Bay, British Columbia	[1] 35	--------	1	*acanthostoma* not typical.
Do	2	6	--------	Stanford Coll., W. F. Thompson.
Do	[1] 13	25	2	Calif. Acad. Sci. Coll., W. K. Fisher.
Clayoquat Sound, British Columbia	--------	1	--------	Stanford Coll., C. H. Gilbert.
Barclay Sound, British Columbia	1 juv.	6	--------	Albatross.
Victoria, British Columbia	2	--------	1	Do.
Straits of Fuca	1	1	--------	D. S. Jordan.
Port Townsend, Wash	--------	1	--------	J. G. Swan.
Puget Sound, Wash	--------	6	--------	D. S. Jordan, Oscar Sturges, C. M. Drake.
Puget Sound (Simeahmoo)	3	8	2	Northwest boundary survey, C. B. Kennerly.
Puget Sound (Tacoma)	5	10	2	F. W. Weymouth.
Orcas Island, San Juan Islands, Wash	[1] 22	10	1	Calif. Acad. Sci. Coll., Ida Oldroyd.
Friday Harbor, San Juan Islands	6	9	2	Do.
Station 4205, vicinity of Port Townsend, Wash., 26 fathoms.	1	1	1 juv. (?)	Bottom, rocks, shells; bottom temperature, 50.8° F
Station 4222, same locality, 39 fathoms	1	--------	--------	Bottom, gray sand, broken shells. R 355 mm., r 46 mm., br 58 mm.
Beatrice, Humboldt County, Calif	--------	1	--------	C. M. Drake.
Trinidad Head, Calif	--------	1	--------	Stanford Coll., W. F. Weymouth.
San Francisco Bay, Calif	--------	1	--------	Stanford Coll., W. F. Hamilton.
Monterey Bay, Calif	--------	1	--------	R. E. C. Stearns.
Carmel Bay, Calif	--------	1	--------	Stanford Coll., H. Heath.

[1] Many intermediates; all stages between *troschelii* and *alveolata*.

EVASTERIAS ECHINOSOMA Fisher

Plate 59, Figures 2, 2*a*–2*h*, 4; Plates 67–69

> *Evasterias echinosoma* Fisher, A New Sea Star of the Genus Evasterias, Proc. U. S. Nat Mus., vol. 69, art. 6, 1926, p. 2, pls. 1, 2.

Diagnosis.—Size large; rays five, long, tapering, stout, more or less swollen, with a very convex abactinal, and a subplane actinal surface. Differing from *E. troschelii* in having uniformly large, mostly subconical, well-spaced abactinal spines; marginal plates unusually high on side of ray, the superomarginals being abactinal in position and generally monacanthid; six (or five) series of actinal plates (generally monacanthid) of which either the upper row or the inferomarginals define the margin of ray; adambulacral plates triplacanthid, or diplacanthid and triplacanthid. Type, R 330 mm., r 51 mm., R = 6.4 r; br = about 60 mm.

Description.—The abactinal surface is armed with rather widely spaced and nearly uniform robust spines, cylindrical at the base, the distal half conical, longitudinally sulcated, bluntly pointed, and in giant specimens with R 300 mm., about 2.5 mm. long, by 1 to 1.5 mm. thick at the base. The distal part of the spine may be slightly swollen so as to appear subcapitate. The spines of the distal portion of the ray are round-tipped, and by a shortening and rounding of the terminal conical portion a subglobose, striated tip results. A majority of spines are so formed in specimens from stations 3281 (2), 3291 (1), 3235 (1), none of which has R greater than 200 mm. In the specimen from station 2842 the spines are slenderer than in the type, tapering, and pointed. The spines do not have regular arrangement. An irregular carinal series is generally fairly well marked, the dorsolaterals standing typically singly (but sometimes in groups or lines of two, three, or even four) on the chief nodes of the reticular skeleton. In some of the very large specimens there are a few very delicate terete spinelets, scarcely longer than the abactinal straight pedicellariae, scattered over the abactinal surface. In the specimens in which the spinelets are more or less grouped, there is rather less uniformity in size, some being of distinctly secondary size. There is a broad and pretty definite supramarginal channel bounded abactinally by a very irregular row of dorsal spines, which usually but not always stand closer together than on the rest of the dorsolateral region.

The superomarginal spines are similar in form to the abactinal spines (following the variations of the latter) and are generally slightly smaller. Typically they stand one to a plate, close together, forming a very well-defined series, characteristically high on the side of the ray, so that the proximal half at least, and sometimes the whole ray is bordered, when viewed from above, by the inferomarginals, or by the first series of actinal spines. This character is accentuated in small examples (R 110 mm.), in which the abactinal area is narrow. Interradially the superomarginal series extends halfway to the center of the disk. Two or three spines occur on the plates of the proximal half of ray in specimens from stations 4796, 3235, and 3291 (one each).

There is a wide intermarginal channel (2 or 2.5 times length of inferomarginal spines). Inferomarginal spines similar to superomarginals, but a little longer (3 or 4 mm. in giant specimens), sometimes one to a plate, sometimes two, or rather irregularly one and two proximally and one distally. The series bends upward interradially, and in some specimens is abactinal (or dorsolateral) in position.

In large specimens there are six series of spiniferous and one short series of spineless actinal plates at the base of the ray. There is considerable variation in the number of spines per plate. All plates may be monacanthid. In this case there are eight regular, spaced, longiseries of spines, of which two are marginal series abactinal in position. (Station 3282.) The outer three or four series are sometimes regularly or irregularly diplacanthid and the inner two or three monacanthid; or the outer row may be monacanthid, the next two irregularly diplacanthid, and the remaining three, monacanthid. (Station 3281.) In a specimen from station 2842 a considerable number of plates are triplacanthid. In large specimens the sixth or inner series of actinal spines extends one-third R measured from center of disk. The actinal spines become gradually a little longer, sometimes heavier and clavate, in passing from the outer toward the inner series. The details of the actinal spines are variable, as in other species. The tips may be compressed and subtruncate, sulcate, or tapered, blunt, or pointed. The smallest specimen (station 3650) with R 46 mm., has four series of actinal plates. The large specimen from Kamchatka (station 4796) with R 265 mm. has but five series of actinal plates. Whether this is constant for large Asiatic examples can not be determined.

The actinal channels are typically well marked, even broad in some cases, so that the rows of spines are distinct and separated.

The adambulacral are triplacanthid and diplacanthid. In large examples most of the plates of the proximal half of the ray are triplacanthid then irregularly diplacanthid and triplacanthid and finally on the distal third of the ray, mostly diplacanthid. The distribution of these numbers will, of course, vary in different individuals. In general the proportion of plates occupied by three spines increases with the size of the animal, the third spine being added on the outer side of the plate. The combs of alternate plates are advanced further into the furrow. The first three plates following the mouth plates are generally monacanthid; then three or four are diplacanthid, following which, after a few plates of three and two, the regular triplacanthid plates commence. The spines are slender, about as long as the inner actinals. The furrow members are slightly tapered; the others, a little stouter, varying from slightly tapered to cylindrical, or somewhat clavate, round tipped to bluntly pointed. The third, outer spine may be shorter than the other two. There are usually five pairs of united plates composing the adoral carina. The large Kamchatkan example is diplacanthid, and near the end of the ray, irregularly diplacanthid and monacanthid.

Actinostome very small. Mouth plates with two apical spines in nearly vertical series, the smaller at the mouth of the furrow, the other (about as long as the plate, and sometimes spatulate) almost directly above it (as viewed from actinal side). The suboral spine, near outer end of plate, is about as long as first two or three adambulacrals.

The papulae have the distribution characteristic of the genus, and are very abundant, especially abactinally, where, in alcoholic specimens they appear to occupy all the space between the prominent circles of crossed pedicellariae surrounding the spines. The size of the areas increases with age; about eight or nine areas can be counted across the ray at base, but the dorsolaterals are very irregular. There is a fairly regular supramarginal row. The intermarginal and actinal rows—eight in all—are typically regular and decrease in size toward the furrow.

Straight pedicellariae (pl. 59, figs. 2, *2a–2f*): There are two sorts, larger and smaller; the larger, usually compressed ovate, wedge-shaped, with the end broadly rounded and the tip of each jaw with two or three denticles, varies from abundant to relatively few on the abactinal surface; they are generally abundant on the intermarginal and actinal integument, and a few occur on the inferomarginal, actinal, adambulacral, and oral spines. They vary to lanceolate obtuse and lanceolate acute. In large specimens the abactinal measure about 0.9 to 1 mm., while the actinal interradial ones are 1.5 mm. long. Much smaller ones are present in variable numbers on the actinal, adambulacral, and oral spines, and are rather sparsely scattered along the furrow face of the adambulacral plates.

Small crossed pedicellariae (pl. 59, figs. *2g*, *2h*) are very abundant singly and in groups among the papulae; in a broad zone around the abactinal and marginal spines; and in half-wreaths on the outer side of the actinal and adambulacral spines. The abactinal measure 0.27 to 0.3 mm. while the adambulacral measure 0.35 to 0.4 mm. (large specimens with R 270 mm. or more). Apparently there is a gradual increase in the number of crossed pedicellariae, especially the papular, with age.

Madreporic body large, subplane, with a row of spinelets on the adcentral border; it is situated a little less than one-third r from center of disk.

Variations.—The chief variations have been noted in the foregoing account.

The example from off Petropavlovsk, Avatka Bay, Kamchatka (pl. 68, fig. 1), suggests a representative of a slightly differentiated race. There is but one large specimen, and therefore no chance to test the constancy of its characters. The abactinal spines are more numerous than in typical east Bering Sea examples and are grouped, or in lines, so that the reticulum of the skeleton is indicated, but not clearly marked; there are but five series of actinal plates, and only four are prominent; the proximal superomarginal plates are polyacanthid; the adambulacrals are diplacanthid, and the straight pedicellariae are few instead of abundant. The small specimen from the Okhotsk Sea, having R 46 mm., has four series of actinals, typical abactinal spines, and very abundant straight pedicellariae.

Anatomical notes.—The carinal plates are four lobed, and strongly imbricated in series. The dorsolaterals are irregular, in outline separated less than their own diameter (occasionally directly overlapping by a lobe), and are connected by elongated secondary ossicles on the coelomic side. These become longer toward the marginal plates, and all underlap strongly the major plates, showing above as narrow connecting pieces or trabeculae of the reticulum, of which the primary plates form the disproportionately thickened nodes. The marginals and actinals are four lobed (the transverse lobes the longer) very strongly imbricated, so that the intervals between the plates are rather small, and the plates decrease in size from the superomarginals to the innermost or seventh series of actinals which is spineless. The upper, or, underlying, lobe of the actinals is the longest and is more or less compressed and carinated.

The adambulacral plates are very short and broad, the width equaling the length of about five consecutive plates. The ambulacrals are also very wide and short, the width of course varying in different parts of the ray. The ambulacral pores are quite slitlike. In large specimens there are 11 ambulacral plates in the length of 10 mm. (about opposite interbrachial angle).

The ovaries of a small specimen (R 123 mm.) are mature and open dorsally close to the interradial line at about mid r. The gonad is roughly spindle-shaped and consists of numerous short subequal lobulated divisions arranged rather symmetrically around a central axis.

Type.—Cat. No. E1237, U.S.N.M.

Type locality.—Station 3278, north of the end of the Alaska Peninsula (56° 12′ 30″ N., 162° 13′ W.); 47 fathoms, fine gray sand; bottom temperature, 38.8° F.

Distribution.—Southern Bering Sea, from Bristol Bay to Unalaska; the coast of Asia from Avatka Bay, Kamchatka, to the Okhotsk Sea; 11 to 48 fathoms, fine sand, mud, pebbles, stones; temperature range 38° to 41.2° F.

Specimens examined.—Thirteen.

Specimens of Evasterias echinosoma examined

Station	Locality	Depth	Nature of bottom	Bottom temperature	Number of specimens	Collection
		Fathoms		° *F.*		
2842	Off north coast Unalaska	41	Pebbles	41	1	U.S.N.M.
3235	Bristol Bay, Alaska	11	Black stones		1	Do.
3241	do	14	Black mud	38	1	Do.
3278	North of end of Alaska Peninsula 56° 12′ 30″ N., 162° 13′ W.	47	Fine gray sand	38. 8	2	Do.
3281	do	36	Gray sand		2	Do.
3282	do	53	Fine sand, green mud	38. 2	1	Do.
3285	do	35	Gray sand	41	1	Do.
3291	Mouth Bristol Bay, near Alaskan Peninsula, 56° 58′ 30″ N., 159° 11′ W.	26	Black sand	41. 2	2	Do.
3650	Okhotsk Sea (to westward of Robben Island).	28	Brown mud, sand		1	Do.
4796	Avatka Bay, Kamchatka, 52° 47′ N., 158° 43′ E.	48	Sand, pebbles, shells		1	Albatross, 1906.

Remarks.—This well-marked species is separated from *troschelii* by several definite characters: (1) The well-spaced, stout, subconical, conical, or occasionally capitate abactinal spines; (2) the unusually numerous actinal plates, there being seven rows in large specimens; (3) the position of the marginal plates relatively high on the side of the ray, so that the superomarginals are abactinal in position; (4) the triplacanthid and diplacanthid adambulacral plates.

A specimen from station 3291 (with R 162 mm. pl. 68, fig. 2) has the abactinal spines rather more numerous, and considerably smaller than in typical specimens. It is not to be confounded with *E. troschelii* forma *acanthostoma,* because the other characters are typical.

Genus STEPHANASTERIAS Verrill

Stephanasterias Verrill, Bull. Essex Inst., vol. 1, 1871, p. 5. Type, *Asteracanthion albulus* Stimpson.

Nanaster Perrier, Expéd. sci. Travailleur et Talisman, pp. 129, 131, 133. Type, *Stichaster albulus* (Stimpson).

Diagnosis.—Small fissiparous Asteriinae with upward of nine rays, and a closely reticulate rather irregular abactinal skeleton consisting of small, lobed or elliptical, imbricating plates, of which the closely imbricated 4-lobed carinals form a definite fairly regular series; actinals absent; marginals low on side of ray, and, like the abactinals bearing several short delicate spinelets; papulae simple, one to several to each area, of which there are upward of four poorly defined dorsolateral and one intermarginal longiseries on either side; adambulacral plates short (compressed) diplacanthid or triplicanthid, without spine pedicellariae; adoral carina consisting usually of one pair of contiguous adambulacrals increasing to three in largest specimens; tube feet in four longiseries; large, toothed, and unguiculate straight pedicellariae; crossed pedicellariae without enlarged terminal teeth; gonads opening low on side of ray in interbrachial channel, intermarginally.

In addition to the type species, *S. gracilis* (Perrier) has been described from the West Indian region (off Florida, Lesser Antilles, Cuba, 56 to 200 fathoms).

Stephanasterias hebes Verrill from *Albatross* station 2766, 10.5 fathoms, off the east coast of South America (lat. 36° 47′ S., long. 56° 23′ W.), is not a *Stephanasterias*, but probably an *Allostichaster*.[26]

STEPHANASTERIAS ALBULA (Stimpson)

Plate 70, Figures 1–5; Plate 71, Figures 1, 1*a*–1*g*; Plate 72, Figure 5

Asteracanthion albulus Stimpson, Invert. Grand Manan, 1853, p. 14, pl. 1, fig. 5.

Asteracanthion problema Steenstrup, Vidensk. Medd., 1854, p. 240.—Lütken, Grönlands Echinodermata, 1857, p. 30; Vidensk. Medd., 1871, p. 300.

Asterias albula Stimpson, Proc. Acad. Nat. Sci., Philadelphia (1863), 1864, p. 142.

Stichaster albulus Verrill, Proc. Boston Soc. Nat. Hist., vol. 10, 1866, p. 351 (var. *nitida*, p. 351).—Ludwig, Arktische Seesterne, Fauna Arctica 1, 1900, p. 479 (literature list).—Von Hofsten, Echinodermen des Eisfjords, 1915, p. 56, fig. 19 (distribution).

Stephanasterias albula Verrill, Bull. Essex Inst., vol. 1, 1871, p. 5; Shallow-water Starfishes, 1914, p. 147.

Description.—The small, close-set groups of dorsolateral spinelets, upward of five to a plate, tend to form close transverse rows, extending from the differentiated carinal series to the inferomarginals which are low on side of ray. Carinal plates somewhat larger than the dorsolaterals, more strongly imbricated and with five or six divaricate spinelets. In a large specimen abactinal spinelets are 0.45 to 0.55 mm. long and are tipped with usually three to six sharp thornlets. In alcocholic specimens the spinelets are skin-covered, papilliform and not easy to differentiate from the crossed pedicellariae which are scattered among them. Papulae small, single or few to an area. Two irregular longiseries of areas nearest carinals are about the size of the plates but two other series on dorsolateral region of ray (the outer one, supramarginal) are usually considerably larger than the surrounding plates.

Superomarginal plates four lobed, closely imbricated, the descending lobe longest. Each bears a transverse (vertical) comb of four or three spinelets similar to the abactinal but sometimes a shade larger. Inferomarginal plates, on ventrolateral border of ray bear an oblique comb of three or four spinelets of which the lower two (or sometimes three), are considerably longer and often much thicker than the superomarginals. In old specimens some of them may be spatulate, or clavate and slightly curved. Usually, however, they are all slender. They are about 1 to 1.25 mm. long.

Adambulacral plates short, so that the combs of three spines per plate (rarely four), are close together and form a cheveux-de-frise along the furrow margin. Plates of the outer attenuate portion of the ray frequently carry two spinelets. The spinelets are subequal to the inferomarginals and like them are sometimes thickened in old specimens. The middle one is often slightly to decidedly compressed and broadened toward the tip.

Each mouth plate carries on the narrow suboral surface two to four tapered spinelets similar to the succeeding adambulacral spinelets (of which there may be only two on the first two or three narrowed adambulacrals). At the base of the innermost oral spine there is a cluster of small lanceolate straight pedicellariae (similar to those which fringe the furrow margin). One to several large unguiculate pedicellariae stand at the surface of the plate.

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[26] West Indian Starfishes, Bull. Univ. Iowa, vol. 7, no. 1, 1915, p. 26, pl. 9, fig. 3.

Crossed pedicellariae (pl. 71, fig. 1*b*), numerous, averaging 0.25 to 0.27 mm. with many as small as 0.225 mm. They are attached at the base, sometimes on the base, of the spinelets around which they form complete or partial circlets. They are present sparingly on the inferomarginal spines, except the inner or lowermost which carries them only sporadically.

Straight pedicellariae roughly of two sorts: (1) Larger, pyriform or ovoid, dentate or unguiculate ones scattered over the surface of the body here and there along the furrow margin, and on the oral plates. (Pl. 71, figs. 1*c*, 1*f*.) These appear to be common only in the largest specimens where they measure from 0.8 to 1.2 mm. (2) Lanceolate blunt forms with or without a few terminal teeth, and much smaller than the above are scattered over the body and along the furrow margin. In most specimens these are the prevalent type and vary greatly in size, from the length of the crossed pedicellariae to 0.5 or 0.6 mm. On big specimens (R 50 mm. or more) they intergrade in size with (1). (Pl. 71, figs. 1*d*, 1*e*.)

Madreporic bodies usually two, in opposite interradii near the margin of disk. Some but not all small, 6-rayed examples have one madreporite. Ordinarily fission takes place on a plane between the two madreporites, but there are a number of exceptions, as for instance the large 7-rayed example, Plate 70, Figure 1, station 3548. Specimens in process of acquiring new rays usually have the second madreporite undeveloped on the regenerating part of the disk.

Type locality.—Grand Manan, New Brunswick (at mouth of Bay of Fundy).

Distribution.—On the Atlantic coast of North America "it is common from low-water mark to 100 fathoms in the Bay of Fundy and off the coast of Nova Scotia. Dredged at more than 100 stations between north latitude 46° 50′ and 35° 12′ 30″. Off Cape Hatteras and off South Carolina it is common in 16 to 50 fathoms. Common south of Marthas Vineyard in 50 to 150 fathoms. In depth its range is 0 to 229 fathoms; in one case recorded from 435 fathoms, off Delaware, and once from 1,253 fathoms." (Verrill, 1914, p. 148.) The species has been taken on the east, south, and west coasts of Greenland as far north as latitude 80°; from Ellesmere Land, Jones Sound, Cumberland Gulf; Iceland; Jan Mayen; Spitzbergen; Murman coast; Barents Sea; Kara Sea and Kara Strait; Matochkin Strait, Nova Zembla. (See Von Hofsten, 1915, p. 57.)

In the north Pacific region the species has been taken in 33 to 350 fathoms from southern Bering Sea to Lynn Canal, southern Alaska.

It has been recorded by Marenzeller (according to Von Hofsten, 1915), from 1,000 to 1,200 meters, Japanese Sea.

The species is probably completely circumpolar in distribution, but it is to be noted that no specimens have been taken in northern Bering Sea, nor from the Arctic Ocean just north of Bering Straits—regions which have yielded other species of arctic sea stars.

Specimens examined.—Seventy-four.

Specimens of Stephanasterias albula examined

Station	Locality	Depth	Bottom	Bottom temperature	Number of specimens	Number of rays
		Fathoms		°*F.*		
3223	Bering Sea, 54° 26′ 15″ N., 165° 32′ W	56	Black pebbles	39	1	7
3257	Bering Sea, 54° 49′ N., 165° 32′ W	81	Gray sand, gravel	39	4	8
					3	7
					1	6
3311	Bering Sea, 53° 59′ 36″ N., 166° 29′ 43″ W	85	Green mud	41	1	7
3331	Bering Sea, 54° 01′ 40″ N., 166° 48′ 50″ W	350	Mud		1	6
					1	[1]4
3548	Bering Sea, 54° 44′ N., 165° 42′ W	91	Black sand	39.5	2	8
					1	7
					3	6
4258	Vicinity Funter Bay, Lynn Canal, Alaska	300-313	Mud	41.2	1	7
					11	6
					1	[1]3
4292	Shelikof Strait, Alaska (off Cape Uyak)	102–94	Blue mud, fine sand	39.8	1	7
4777	Petrel Bank, Bering Sea, 52° 11′ N., 179° 49′ E	52–43	Fine gravel		5	8
					1	6
4778	do	43–33	Fine black gravel		1	8
4779	do	54–56	Broken shells, pebbles, sand		1	6
4787	Off Copper Island, Commander Islands	54–57	Green sand		1	8
					1	6
4788	do	57–56	do		1	8
4790	Off Cape Monati, Bering Island, Commander Islands.	64	Pebbles		2	6
4791	do	76–72	Rocky		10	8
4792	do	72	Pebbles		1	[1]4
					2	7
					14	8
	Unalaska				1	8
	Unalaska (Captains Harbor, Dall)				1	7

[1] Divided.

Genus APHANASTERIAS Fisher

Aphanasterias Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 12, 1923, p. 601.—Type, *A. pycnopodia* Fisher.

Diagnosis.—Resembling a large 5-rayed *Stephanasterias* in general appearance, but differing in having compound papulae, very regularly diplacanthid adambulacrals, diplacanthid inferomarginals, monacanthid superomarginals and abactinals, extremely compressed ambulacrals, and in lacking fissiparity. No actinal plates (except possibly a few interradial rudiments); marginals small, on ventrolateral border of ray; abactinal skeleton irregularly reticulate, the carinals arcuately and rather irregularly four sided, and imbricated in a definable series; dorsolaterals very irregular transversely elongate; adambulacrals and ambulacrals much compressed, the adoral carina well developed, with four to six pairs of plates involved; gonads opening interradially and dorsally; crossed pedicellariae in circlets around the abactinal and superomarginal spinelets; in tufts on the inferomarginals; conspicuous unguiculate straight pedicellariae; no pedicellariae whatever on the adambulacral spines.

Remarks.—To the differences separating this genus from *Stephanasterias* might well be added "a better developed adoral carina." The small specimens of *Stephanasterias* ordinarily found in collections have only the first postoral pair of adambulacral plates in contact interradially, but a large specimen which I have (station 3548, Bering Sea) has three pairs in contact.

One of the best differences seems to be the compound structure of the papulae, to which the finely papillose appearance of the interspinal spaces is due. In *Stephanasterias* the papulae are simple papillae, not at all subdivided.

Aphelasterias japonica superficially resembles *Aphanasterias pycnopodia* but its rays are stouter. Its spinelets are more like those of *Stephanasterias*. There are three or four inferomarginal, and the same number of superomarginal spines in vertical (transverse) combs, the abactinal spinelets are in small groups, and the papulae are simple. The straight pedicellariae are inconspicuous and lanceolate, and the crossed pedicellariae are quite small (0.16 to 0.18 mm. long; pl. 72, fig. 5). As in *Aphanasterias* the adambulacral plates are regularly diplacanthid, the ambulacrals are much compressed, and the adoral carina is narrow and in large specimens composed of three to five pairs of plates. But the resemblance of this feature to that of *Aphanasterias pycnopodia* is not strong, since the carina is much more constricted in *Aphelasterias* and the first and second adambulacrals are longer than the succeeding.

In *Stephanasterias* the gonads open at the base of the ray, between the superomarginal and inferomarginal plates; in *Aphelasterias* they are attached to the inner surface of the superomarginals a short distance from the base of the ray (a trifle less than r), but the ducts open just *above* the superomarginals. In the present genus the attachment point is *close to the interbrachial* angle, above the superomarginals (which turn upward rather abruptly as they approach the angle) and at the dorsal entrance of interbrachial or axillary channel. In the other two genera the aperture is low on the side of the ray.

APHANASTERIAS PYCNOPODIA Fisher

Plate 70, Figures 6, 7; Plate 72, Figures 1–3

Aphanasterias pycnopodia Fisher, Ann. and Mag. Nat. Hist., ser. 9, vol. 12, 1923, p. 601.

Diagnosis.—Rays five; R 76 mm., r 7 mm., R = 10.8 r; breadth of ray at base, 9 or 10 mm.; disk very small, rays very slender and gradually tapering to an attenuate extremity; abactinal surface well arched; marginal plates on the ventrolateral margin; tube feet very crowded, sometimes five or six across the furrow; actinostome small, sunken; adoral carina well developed; abactinal spinelets small, solitary, scattered, except the carinals which form regular series; superomarginals forming one, inferomarginals two, and adambulacral spinelets two regular longiseries; large unguiculate straight pedicellariae; crossed pedicellariae in small circles around the abactinal and superomarginal spinelets, and in tufts on the inferomarginals; gonads opening dorsally.

Description.—The ray has few trenchant features which may be used as recognition characters. The well arched abactinal surface is beset with short, conical or conico-cylindrical, sharp or bluntly pointed, spaced spinelets, one to a plate and averaging about 0.5 to 0.6 mm. in length. Those of the carinal series form a definite line and are spaced about their own length apart, and are stouter than the adjacent dorsolateral spinelets, which increase slightly in size toward the superomarginal series. The dorsolateral spinelets are more widely spaced, do not form regular series, and about four or five can be counted in the width of each dorsolateral area, at base of ray. There is one superomarginal spine, a little longer than the carinals, and just below it two slightly longer, tapered inferomarginal spinelets, the upper the shorter. The three spines form three longitudinal series, the two inferomarginal being on the ventrolateral margin of the ray, the superomarginals spaced above them by about the length of a spine. Each abactinal and superomarginal spinelet is surrounded by a collar of crossed pedicellariae borne on a sheath while the inferomarginals carry a small cluster, that of the outer being the larger. It is often absent from the inner or lower spine. Scattered irregularly among the abactinal and marginal spines are unguiculate straight pedicellariae sometimes longer than the spinelets. A relatively huge one is found in each actinal interradial area.

The abactinal skeleton is of the irregularly reticulate type. The carinals are irregularly and the marginals fairly regularly four lobed and directly imbricated except in the case of the proximal carinals which may have an internal connecting ossicle. The dorsolaterals are quite irregular. Actinal plates absent. (Pl. 72, fig. 1.)

Papulae compound, four to eight small papillae to a cluster and two to four clusters to a mesh, irregularly distributed. Each cluster represents a subdivided or compound papula. Intermarginal areas with one cluster. The papulae fill in the spaces between the circumspinal crowns of pedicellariae and give the surface a minutely papillose appearance.

Adambulacral plates juxtaposed closely to inferomarginals, very short, so that the consecutive pairs of spines are closely in contact. The spines, which are slender, slightly tapered, and blunt, are nearly equal, a little shorter but very much slenderer than the lower inferomarginal spine, and form two regular longiseries on the furrow margin. The proximal spines measure 1.25 mm. A cordon of large pedunculate lanceolate straight pedicellariae (proximally 0.95 mm. long) occupies the furrow face of the adambulacrals. They sometimes extend between the furrow spines, but the latter carry no pedicellariae whatsoever.

The actinostome is small and constricted, and the adoral carina rather well developed, consisting of about five postoral pairs of adambulacrals joined on the interradial line. Mouth plates small, compressed, each with two rather stout, flattened, blunt spinelets, the inner close to the mouth. At the base of the inner spinelet is a lanceolate straight pedicellaria, and frequently a larger unguiculate one (with two claws to a jaw) occupies a position between the suboral and actinostomial spinelet (one to each oral angle).

Ambulacral ossicles very much compressed; ambulacral pores very narrow slits, the two mesial rows not exactly straight, so that the tube feet appear in more than four series, in the broadest portion of the ray.

Crossed pedicellariae, distributed as indicated above, are of fairly uniform size (about 0.3 mm.), though small ones (0.22 mm.) are found scattered here and there among the larger. They lack enlarged teeth on the terminal expanded portion but have numerous small denticles on the shank.

The straight pedicellariae of the abactinal and lateral portions of rays and disk are very obtuse as seen in profile, and from two to three times as long as broad. The jaws are scarcely broadened distally and end in one to three prominent claws. Often one claw fits between two of the opposing jaw. The largest abactinal are about 1 mm. in length. The large actinal intermediate pedicellaria (1.5 to 1.7 mm.) has heavier, distinctly spatulate jaws with two or three interlocking claws. The adambulacral pedicellariae attached by fleshy peduncles to the furrow face of the plates are lanceolate, without teeth, except incipiently, on the adoral carina. In life the peduncles are probably capable of considerable extension.

Madreporic body 3 mm. in diameter, with pores rather than striae, and situated a little nearer to interbrachial angle than midway of r.

Gonads small, opening in interbrachial angle above the superomarginal plates. Ampullae single, pyriform, but somewhat two lobed when contracted.

Type.—Cat. No. E 1505, U.S.N.M.

Type locality.—Station 2847, vicinity of Shumagin Islands (55° 01′ N., 160° 12′ W.), 48 fathoms, fine gray sand, bottom temperature 42° F.; one specimen.

Remarks.—This species resembles a large, sparsely spined *Stephanasterias albula* with two instead of three inferomarginal spines, one instead of three or four superomarginal spines, and two instead of three adambulacral spines. The abactinal spinelets of *Stephanasterias* are in little groups which tend to form transverse rows, in large specimens especially. Most North Atlantic examples of *Stephanasterias albula* are quite small, but I have a specimen from 91 fathoms, Bering Sea (station 3548) in which the longest rays are 58 mm. The large straight pedicellariae of *Stephanasterias* have more numerous teeth and are of different form.

Genus PISASTER Müller and Troschel

Asterias (part) Brandt, Prodromus, 1835, and authors.

Pisaster Müller and Troschel, Archiv f. Naturgesch. 6 Jahrg, vol. 1, 1840, p. 367; System der Asteriden, 1842, p. 20. Type, *Asteracanthion margaritifer* Müller and Troschel (=*Asterias ochracea* Brandt).—A. Agassiz, Mem. Mus. Comp. Zoöl., vol. 5, 1877, p. 96 (citation).—Fisher, Smithsonian Misc. Coll., vol. 52, 1908, p. 89; Zool. Anz., vol. 33, 1908, p. 358.—Verrill, Amer. Journ. Sci., vol. 28, 1909, p. 63; Shallow-water Starfishes, etc., 1914, p. 67.—Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 17, 1926, p. 556.

Asteracanthion (part) Müller and Troschel, System der Asteriden, 1842, p. 20.

Calliasterias Fewkes, Bull. Essex Inst., vol. 21, 1889, p. 33. Type, *Asterias exquisita* de Loriol (=*Pisaster giganteus* young).

Diagnosis.—Large, heavy-ossicled, monacanthid Asteriinae having an irregularly articulate abactinal skeleton; few to numerous short subcapitate abactinal spines; two to five longiseries of spiniferous actinal plates; a small, deeply sunken actinostome; long, upcurved adoral carina; extremely compressed ambulacral ossicles; unique furcate straight pedicellariae, each jaw of which ends in one long and one short hyaline blade; no pedicellariae on adambulacral spines; gonads opening dorsally.

Description.—Abactinal skeleton irregularly reticulate; the carinals and marginals at first four lobed; one or more intermarginal ossicles; in old specimens secondary ossicles are developed between consecutive inferomarginal and actinal plates as well as between the plates of the transverse series; normally two inferomarginal and one actinal spine to a plate, each with a thick pad of crossed pedicellariae on outer side; abactinal spines variable, but uniformly short, subconical to subglobose, the more or less specialized distal portion longitudinally scored; in old specimens there may be more than five longiseries of actinal plates, and the skeleton is strengthened by the addition of new ossicles on the coelomic side. Actinostome small, deeply sunken, the adoral carina composed of upward of 15 pairs of contiguous adambulacrals; proximal end of furrow petaloid in form; ambulacral ossicles very much compressed so that the tube feet stand in six rows at the widest part of furrow; interbrachial septum strongly calcified, and extending about two-thirds toward center of disk; aperture from arm coelom into disk small (about twice diameter of madreporite in *ochraceus*); a series of transverse, vertical, superactinal partitions or buttresses connects the adambulacral and inferomarginal plates, the spaces between them forming a series of coelomic cavities above the actinal plates. Papulae numerous, slender, in clusters, the actinal very long; the clusters originate from a common hernialike swelling of the skin which, with bases of papulae, is armed with tiny lanceolate pedicellariae. (Pl. 77, fig. 5.) Stomach eversible; pyloric coeca long, bulky; intestinal coecum with slender irregular lobes; gonads, extensive racemose tufts, opening dorsally.

Small furcate straight pedicellariae (usually mingled with the crossed) are peculiar to the genus and consist of a basal piece, longer than broad, and two curved jaws each ending in two thin hyaline blades, characteristic for each species. One blade is always much longer and broader than the other. Large sessile, ovoid, "stone-hammer" pedicellariae with narrow to broad ovate jaws and terminal interlocking teeth are found scattered over the body but especially in the intermarginal and in the actinal interradial channels; very small lanceolate dermal straight pedicellariae are common especially among the papulae and in long pedunculate clusters attached to the furrow margin, often surrounding one or more large lanceolate, toothed pedicellariae. Crossed pedicellariae, in dermal tufts or surrounding spines, are numerous and lack any conspicuously enlarged terminal teeth. (Actinostomial ring, pl. 76, fig. 1.)

Remarks.—The most characteristic features of this genus are the furcate pedicellariae, which are unique; the broad actinal area; and the long adoral carina bent upward to the deeply sunken, small, actinostome. These are all indications of high specialization, as are the very numerous, crowded, ambulacral ossicles and small mouth plates. If we assume as primitive a type similar to *Hydrasterias*, with open oral angle (that is, without adoral carina), with biserial tube feet and uncrowded ambulacral ossicles, no actinal plates, and few, regular, dorsolaterals, then *Pisaster* is one of the most specialized genera in the family. It is moreover restricted in habitat, as specialized genera are likely to be, being confined to the Pacific coast of North America.

Verrill (1914, p. 67) lays considerable emphasis upon the large unguiculate pedicellariae as peculiar features of this genus, but this type is widely distributed through the family and is in no way characteristic of *Pisaster* alone. If these pedicellariae were diagnostic of *Pisaster* they would exhibit peculiarities for each species as do the unique furcate pedicellariae. Nothing similar to the latter have been described for any sea star. No mention of them is made by Verrill, though they are very numerous in his *Pisaster papulosus* (=*brevispinus*) as well as in other forms, except southern California races of *P. ocharaceus* and *P. giganteus* where they are rather scarce.

The species are extremely variable. As is often the case when abundant material is available, specific distinctions become less distinct. Three species are sharply differentiated, without the least indication of intergradation. All the other taxonomic divisions have been arranged under one or another of these three—*ochraceus*, *giganteus*, *brevispinus*.

In the left column are the forms recognized in this synopsis and in the right column the names which the same forms bear in Verrill's Shallow-water Starfishes.

Pisaster ochraceus forma *ochraceus*	*Pisaster ochraceus* (p. 69). *Pisaster fissispinus* (p. 76).
Pisaster ochraceus f. *nodiferus*	*Pisaster ochraceus* var. *nodiferus* (p. 72).
Pisaster ochraceus f. *confertus*	*Pisaster confertus* (p. 73).
Pisaster ochraceus segnis	*Pisaster ochraceus*.
Pisaster brevispinus f. *brevispinus*	*Pisaster brevispinus* (p. 77).
Pisaster brevispinus f. *paucispinus*	*Pisaster papulosus* (p. 91). *Pisaster paucispinus* (p. 98).
Pisaster giganteus	*Pisaster lütkenii* (p. 83). *Pisaster lütkenii* var. *australis* (p. 88). *Pisaster giganteus* (p. 97).
Pisaster giganteus capitatus	*Pisaster capitatus* (p. 81).
	Pisaster grayi (p. 97).

Pisaster grayi Verrill is a phantom species, the origin of which is traceable to a mistake in Perrier's Révision des Stellérides, page 68. Perrier there described the types of Gray's *Asterias katherinae* (=*Leptasterias polaris katherinae*) as having *monacanthid adambulacrals*, whereas the types (which can be fixed with perfect precision) all have diplacanthid adambulacrals. Verrill accepted Perrier's description, but inferred that these supposedly monacanthid specimens were a *second* set of 6-rayed asterids which Perrier had mistaken for the types of *Asterias katherinae*. No such second set exists, however. *Pisaster grayi* is therefore without status. The name must be regarded as a synonym of *Leptasterias polaris katherinae*.

PISASTER OCHRACEUS (Brandt)

Asterias ochracea Brandt, Prodromus, 1835, p. 69 (Sitka).—Stimpson, Boston Journ. Nat. Hist., vol. 6, 1867, p. 527, pl. 23, fig. 2.—Verrill, Trans. Conn. Acad. Sci., vol. 1, 1867, pp. 325, 326.—Perrier, Rév. Stell., 1875, p. 70.—Whiteaves, Trans. Royal Soc. Canada, vol. 4, 1887, p. 116.—Agassiz, Mem. Mus. Comp. Zoöl., vol. 5, 1877, p. 96, pl. 11, figs. 1–7.—Sladen, Challenger Asteroidea, 1889, pp. 566, 826.—H. L. Clark, Bull. Mus. Comp. Zoöl., vol. 51, 1907, p. 67, pl. 6, fig. 3.

Asterias janthina Brandt, Prodromus, 1835, p. 69 (Sitka).

Asteracanthion margaritifer Müller and Troschel, System der Asteriden, 1842, p. 20 (Sitka ?).

Asterias conferta Stimpson, Proc. Boston Soc. Nat. Hist., vol. 8, 1862, p. 263 (Puget Sound).—Verrill, Trans. Conn. Acad. Sci., vol. 1, 1867, p. 326.—Perrier, Rév. Stell., 1875, p. 71.—Sladen, Challenger Asteroidea, 1889, pp. 566, 820.—Bell, Proc. Zool. Soc., 1881, p. 494.—Whiteaves, Trans. Royal Soc. Canada, vol. 4, 1887, p. 116.—De Loriol, Mém. Soc. Phys. et Hist. Nat. Genève, vol. 32, pt. 2, 1897, p. 171, pl. 3, figs. 1–1*g*.

Asterias fissispina Stimpson, Proc. Boston Soc. Nat. Hist., vol. 8, 1862, p. 264 (Shoalwater Bay, Wash.).—Verrill, Trans. Conn. Acad. Sci., vol. 1, 1867, p. 326.

P[*isaster*] *ochraceus* Verrill, Amer. Journ. Sci., vol. 28, 1909, p. 63.

Pisaster ochraceus Fisher, Smiths. Misc. Coll. vol. 52, 1908, p. 89.—Verrill, Amer. Nat. vol. 43, 1909, pp. 542, 544, 548; Shallow-water Starfishes, 1914, p. 69, pl. 21, figs. 1, 2; pl. 49, figs. 3–3*d*; pl. 56, figs. 3, 3*a*.—H. L. Clark, Bull. Amer. Mus. Nat. Hist., vol. 32, 1913, p. 203 (San Diego).—Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 17, 1926, p. 557, pl. 19, fig. 1; pl. 20, figs. 1, 2, 4.

Pisaster ochraceus var. *nodiferus* Verrill, Shallow-water Starfishes, 1914, p. 72, pl. 56, figs. 3, 3*a* (Monterey to Sitka).
P[isaster] confertus Verrill, Amer. Journ. Sci., vol. 28, 1909, p. 63.
Pisaster confertus Verrill, Shallow-water Starfishes, 1914, p. 73, pl. 38, figs. 1, 2; pl. 53, fig. 2.
Pisaster fissispinus Verrill, Shallow-water Starfishes, 1924, p. 76, pl. 39, figs. 1, 2.

Diagnosis.—A usually thick-rayed *Pisaster* with numerous small subcapitate, striated abactinal spines arranged in a very irregular reticulate pattern on dorsal and lateral surface of rays, or in detached convex groups, especially on outer part of ray. Actinal spines longer than the abactinals, clavate, striate, in upward of six longitudinal series. Furcate pedicellariae with the undivided basal portion of jaw about equal in length to the longer of the two hyaline blades (which has the upper edge decidedly uneven in most cases). (Pl. 74, figs. 1, 2.)

Description.—The species is so variable that a composite description is impossible. There are three fairly well marked formae which freely intergrade. Two of these have been heretofore ranked as species.

Forma OCHRACEUS (Brandt)

Plate 73, Figure 1; Plate 74, Figures 2, 2*a*; Plate 75, Figures 1–4, 5*a*, 5*b*; Plate 76, Figures 1, 4, 5, 5*a*, 5*b*, 6, 6*a*; Plate 79, Figures 1, 6; Plate 80; Plate 81, Figure 3; Plate 83, Figure 1; Plate 85, Figure 1

This form stands between *confertus*, with small spinlets, and *nodiferus* characterized by stout subglobose abactinal tubercles in more or less isolated convex groups or heaps. It is assumed to be the typical form, and it was so regarded by Stimpson when he described *confertus* as a distinct species. The only specimens of *ochraceus* from Sitka, the type locality, examined by me (pl. 81, fig. 3) are referable to this forma. But *Asterias janthina* Brandt, also described from Sitka, is almost certainly the common purple phase of *confertus* so conspicuous at Departure Bay, British Columbia.

An average specimen from Monterey Bay measures R 140 mm., r 40 mm., breadth of ray at base, 40 mm. Specimens reach twice this length of ray; rays may be relatively broader. Sitka example: R 115 mm., r 36 mm., breadth of ray at base, 43 mm.

The disk is normally convex or rather high arched owing to the deeply sunken actinostome; the rays are arched, normally subcircular in cross section; the actinal surface, viewed from below, slopes downward to the border of the narrow ambulacral furrow, which broaden aburptly at base of ray. The abactinal skeleton extends low on the side of the ray, the superomarginal plates being near the actinal surface and separated from the inferomarginals by a relatively narrow but well-defined channel. The entire skeleton is very robust and rigid, the dorsal forming an irregular reticulum on either side of the rather irregular carinal series. The skeletal ridges are made up of very numerous small irregular plates of a great variety of shapes and sizes, several layers thick in mature specimens, bound together by extremely tough tissue. The intervals are sunken, and are subdivided by much lower trabeculae not externally visible even in dried examples unless treated with caustic potash. Between the secondary trabeculae, defining the actual intervals of the skeleton, emerge the numerous clusters of papulae, very conspicuous in life. Among these and surrounding them on the slopes of the higher ridges are very numerous clusters of crossed and furcate, straight pedicellariae, the latter predominating in most cases. Along the meandering summit of the higher ridges, above this closely packed mass of papulae and pedicellariae, are the stout small spines with subglobose striate ends (pl. 75, figs. 5*a*) arranged usually in single file, sometimes by twos on the carinal series, or forming small groups at the nodes. These tubercles are usually nearly uniform but variations occur in which there is considerable disparity in size.

The variations in the pattern formed by the abactinal spines are as numerous as the individuals of the species, typical examples being figured.

The superomarginal spines are not different from the abactinal though occasionally a little larger than those directly above them. The plates carry usually one spine, sometimes two, especially at nodes. Some variations have a considerable number of the plates with two marginal spines, or one accompanied by two smaller spinelets. A few accessory spinlets appear sometimes on the intermarginal plates.

Inferomarginal plates with usually two spines in an oblique series, with upward of six similar actinal spines between them and the adambulacral system. Actinal spines one to a plate. These spines are longer and more clavate than the abactinal, the ornate fluting being interrupted on the outer side for the attachment of a dense cluster of crossed pedicellariae. The actinal armature is dense and efficient. In life very long slender pointed papulae extend far beyond the spine tips, to such an extent as to nearly hide the armature on the proximal part of the ray.

Adambulacral plates inconspicuous, narrow, with a single slender, tapering, blunt, terete or flattened spinelet. The spinelets are fairly regular, very closely placed, about as long as the inner actinals and they increase in length over the area where the furrow is broadened, at base of ray, to decrease again on the long adoral carina.

The adoral carina along its inner half is narrower than the mouth plates and is composed of upward of 10 pairs of plates. It bends downward (as viewed from the oral surface) to the oral angle. (Pl. 75, fig. 2.) The very small actinostome is guarded by the stout tapering oral spines, which are stouter than the adjacent adoral spines. One or two stand on the free margin and a longer suboral on the middle of the surface. (Pl. 75, fig. 2; pl. 79, fig. 1.) Less often there are three flattend actinostomial spinules. Length and thickness is extremely fariable even in specimens from the same region.

Crossed pedicellariae (pl. 73, figs. 1, 1*a*): Abundant, mixed in varying proportions with furcate straight, on abactinal plates and, practically without furcate straight, in dense clusters on inferomarginal and actinal spines. They are smaller than in typical *nodiferus* being 0.27 mm. long but differ in no important details (Sitka, Monterey).

Straight pedicellariae: (*a*) The characteristic *Pisaster* bifid furcate pedicellariae are very numerous abactinally, and sometimes intermarginally. Clusters composed almost entirely of them are found in the bottom of the hollows among the abactinal papulae. Near the bases of the spines they accompany the crossed form. They measure 0.27 mm. broad by 0.22 high (Sitka); 0.25 by 0.25 mm; 0.29 by 0.3 (Monterey) (Pl. 74, fig. 2; pl. 79, fig. 6.)

(*b*) Undifferentiated lanceolate, of very small size (many as small as 0.13 mm. long), are scattered over all the papular areas. These are similar to Plate 76, Figure 6*a*. Clusters of tiny lanceolate pedicellariae surrounding a large one, at the end of long peduncles, are distributed all along the furrow face of the adambulacral plates—not on all the plates, but here and there. (Pl. 76, figs. 6, 6*a*.) In some dried specimens these appear, superficially, to be attached to the furrow spines. In no instance has a pedicellaria been found attached to a furrow spine. The central pedicellaria is commonly 1 mm. long and is sometimes more robust than Figure 6.

(*c*) On all surfaces of the body but especially actinally and intermarginally are found the heavy, subconical, denticulate pedicellariae whose exact form is shown on Plate 76, figures 4, 5. Figures 2, 3, and 7, although representing forma *confertus* are also typical of some specimens of *ochraceus*. The largest are found on the actinal interradial angle and commonly measure 1.5 mm. in length. The abactinal are commonly 0.5 to 1 mm. long. In some examples, without apparent reference to locality (Monterey, Crescent City, Calif.) the denticulate pedicellariae are rather scarce abactinally.

Madreporic body, conspicuous, situated about one-third r from center of disk; striae fine, branched, irregularly centrifugal.

Color in life.—There are commonly three principal color phases—brown (yellowish brown to dull sepia); brownish purple to dull purple; rather bright ochraceous yellow. The brown phase varies to olive, mottled with dull gray green, and also intergrades through brownish purple with the dull bluish purple phase. The latter is less vivid than the color of forma *confertus*. The yellow phase is less common at Monterey than the brown and purple-brown.

Distribution.—This typically intertidal form has been taken as deep as 48 fathoms off Monterey, Calif. It is the typical form of the open sea coast, from Sitka to Point Sal, Calif., where *confertus* appears never to occur. It occurs less commonly, along with *confertus*, in the protected waters of Puget Sound and tributaries, and in the many quiet bays and inlets opening upon the remarkable channel which separates Vancouver Island from the mainland. In these waters *confertus* is the dominant form but intermediates frequently occur. It is absolutely impossible to allocate all specimens since the differences between the formae are relative only.

Remarks.—The type of Stimpson's *Asterias fissispina*, from Shoalwater Bay, Wash., has been carefully examined. The furcate straight pedicellariae are typical for *Pisaster ochraceus*. The specimen was dried without first being preserved in alcohol so that the rays have become unnaturally flattened and the spinebearing ridges of the abactinal skeleton appear to outline rather large areas. But in *P. ochraceus* there is wide variation in this respect. The ventral spines have a deep groove on the outer side. Some of these and some of the dorsolaterals are slightly bifid or malformed at the tip, not an uncommon occurrence in old animals. There are no grounds for regarding this other than as an individual variant of *ochraceus*—one reason perhaps that no other specimens have been found. (For figures see Verrill, pl. 39.)

Dr. A. Djakonov, of the museum of the Academy of Sciences, U. R. S. S., kindly undertook to find the type of Brandt's *Asterias ochracea*. This involved reviewing all the specimens of *Pisaster* in the museum. Doctor Djakonov writes that the real type is not in existence. There are several specimens collected by Wosnessenski, including two resembling *nodiferus* from California, 1841; and three of forma *ochraceus*, without locality. There are also two specimens well preserved in alcohol of a variety near *nodiferus*, labeled by Brandt "*Asterias margaritifera*—Sitcha." There is no type existing of *Asterias janthina* Brandt.

Forma CONFERTUS (Stimpson)

Plate 73, Figure 2; Plate 74, Figures 1, 1*a*, 1*b*; Plate 75, Figure 5; Plate 76, Figures 2, 3, 7; Plate 81, Figures 1, 2; Plate 82, Figures 2, 3, 4; Plate 86, Figures 2, 4, 7

Asterias conferta Stimpson.
Pisaster confertus Verrill.
Pisaster ochraceus forma *confertus* Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 17, 1926, p. 559, pl. 20, fig. 1.

The type of Stimpson's *Asterias conferta* was taken at Simeahmoo, Puget Sound, by Dr. C. B. Kennerly (No. 1275 U. S. Nat. Mus.). I have examined it several times and it is figured by Verrill. (1914, pl. 38.) A number of my specimens from near Tacoma, Wash., practically duplicate the type, but others from Departure Bay, Union Bay (Bayne Sound), and Boundary Bay, British Columbia, have the characteristics of the variety in an accentuated form. In these the small dorsal spinules are much more numerous and are three or four, sometimes upward of seven or eight, to a plate along the carinal series and on the stellate apical system of the disk. (Pl. 81, fig. 1; pl. 82, fig. 2.)

Confertus intergrades with *ochraceus* (Departure Bay, British Columbia, the sounds of Washington) and it also develops acervate varieties less distinct but parallel to *nodiferus*. (Pl. 82, fig. 3.)

In forma *confertus* the abactinal spinelets are smaller and frequently more numerous than in *ochraceus* (pl. 75, fig. 5), the majority only 0.8 or 0.9 mm. long and relatively slender. Some specimens (as those from Departure Bay and Boundary Bay, British Columbia, pl. 81, fig. 1; pl. 82, fig. 2) carry three to eight spinelets on most of the carinal and primary apical plates. Other specimens have the spinelets in single file, or with the slight irregularity in number normal to *ochraceus*. (Pl. 82, fig. 4.) The superomarginal plates usually carry three or four spinelets giving the armature a different and more crowded appearance than that of *ochraceus*. In some cases the actinal spines are slightly slenderer than those of *ochraceus;* in others there is no difference, and I am unable to find any *constant* actinal features by which *confertus* can be distinguished from *ochraceus*.

Crossed pedicellariae (pl. 73, fig. 2): These are similar in size, form, and distribution to those of *ochraceus*.

Straight pedicellariae: (*a*) The furcate pedicellariae are very numerous but appear to be exactly the same as those of *ochraceus*. That shown on Plate 74, Figure 1*a*, is intermediate between the furcate and the ordinary broadly lanceolate, undifferentiated type. The larger measure 0.28 by 0.28 mm.

(*b*) The undifferentiated lanceolate pedicellariae are very numerous, rather more so than in *ochraceus*, especially abactinally.

(*c*) The denticulate pedicellariae are similar to those of *ochraceus* but often more conspicuous owing to the smallness of the spines. They are usually more numerous, but there is no constant difference in form. Especially large ones (1 to 1.5 mm. long) are found on the actinal interradial angle, and along the intermarginal channel. (Pl. 76, figs, 2, 3, 7.)

As in *ochraceus*, both thicker and slenderer rayed specimens occur. At Departure Bay, British Columbia, where the form is very common, mature examples range from 100 to 170 mm. major radius. Larger examples of course occur in favorable situations.

Color in life.—The prevalent color at Departure Bay, British Columbia, is purple. This analyzes as follows: The small spines, whitish; adjacent ruffs of small crossed and furcate pedicellariae rich aster purple or pansy purple, this area widening as the violet papulae are contracted. When the papulae are fully extended the animal is bluer; when contracted, the aster purple predominates. This color extends to edge of furrow. Tube feet, pale yellow.

Another less common phase—vinaceous rufous, reticulated lighter along the spiniferous ridges, paler below. Sometimes varied with orange rufous.

Another less common phase—madder brown, papulae very dark maroon, the color extending to furrow; tube feet, pale yellow.

Specimens from Union Bay, Bayne Sound, British Columbia, are labeled "bluish purple."

A specimen from Boundary Bay, British Columbia, intermediate between the specimen figured (pl. 81, fig. 1) and the Sitkan example of *ochraceus* (pl. 81, fig. 3) was pansy violet with white spines (F. W. Weymouth).

Distribution.—In the list of localities it will be seen that this form is practically confined to the quiet bays and sounds of Washington, British Columbia, and southern Alaska. It is difficult to escape the inference that the characteristic small spinelets of the abactinal area are correlated with quiet water, but that this is not the only factor is evidenced by the presence, along with *confertus*, of forma *ochraceus* and *nodiferus*, the latter found on open coasts and also in deep water (Monterey Bay). There is nothing approaching a sharp line of distinction between *ochraceus* and *confertus*.

Type of forma confertus.—Cat. No. 1275, U.S.N.M., Puget Sound (Simeahmoo), Wash.

Forma NODIFERUS Verrill

Plate 73, Figures 3, 7; Plate 75, Figure 5*c*; Plate 82, Figure 1; Plate 86, Figures 1, 3, 5, 6, 8, 9

Pisaster ochraceus var. *nodiferus* VERRILL, 1914, p. 72, pl. 56, figs. 3, 3*a*.

Pisaster ochraceus forma *nodiferus* FISHER, Ann. Mag. Nat. Hist., ser. 9, vol. 17, 1926, p. 560.

Abactinal spines stout, globose, or depressed-globose, finely striated, larger than in forma *ochraceus* (pl. 75, fig. 5*c*) and congregated in well separated convex groups or heaps, three or four to a dozen unequal or subequal tubercles to a group. In the center of the disk there is usually a well defined stellate palisade of spines surrounding a central group of tubercles and from the points of the star a carinal series of tubercles often extends half the length of the ray but as often is entirely absent, or represented here and there by unequal tubercles. The spaces between the groups of tubercles are usually entirely free from spines, or in intermediate forms have more or less reticulation at base of ray and more complete isolation and prominence of the groups distally.

The actinal surface is similar to that of forma *ochraceus*.

Crossed pedicellariae (pl. 73, fig. 3) are similar in form to those of *ochraceus* proper but a little larger. Forma *nodiferus*, Monterey, 0.30 to 0.36 mm.; Tongass, Alaska, 0.31 mm. Forma *ochraceus*, Monterey to Sitka 0.27 mm. (some as small as 0.25 mm.).

Straight pedicellariae: *a.* The furcate type resemble those of *ochraceus* and vary somewhat in abundance. On a specimen (No. 18146) from Puget Sound, near Tacoma, they are much more abundant than the crossed; Tongass, Alaska, less abundant; Sausalito and Monterey, Calif., much less abundant. In this form there is a tendency to lose the furcate pedicellariae with decrease in latitude.

b. The lanceolate form appears to be about as numerous as in *ochraceus*.

c. The large denticulate pedicellariae are very numerous in the northern examples, less numerous in the southern. They are rather variable in form; some of the proximal intermarginals develop 8 to 10 teeth whereas the usual number is 4 to 6.

Color of forma *nodiferus* follows closely that of *ochraceus*. A number of specimens from Monterey Bay were colored: Ground tint grayish olive to tea green and light artemisia green, with large patches of rich olive brown, raw umber, and Van Dyke brown.

Distribution of forma nodiferus.—Southern Alaska to northern Lower California (south of Point Conception as a prevalent form of subspecies *segnis*).

Type locality of Pisaster ochraceus.—Sitka, Alaska.

Distribution of Pisaster ochraceus.—Southern Alaska to Point Conception, Calif.

Specimens examined.—One hundred and seventeen in addition to many hundreds from Monterey, and very numerous living examples at Departure Bay, British Columbia.

Specimens of Pisaster ochraceus examined

Locality	f. *ochraceus*	f. *confertus*	f. *nodiferus*	Remarks
Sitka, Alaska	3	--------	--------	
Revillagigedo Island, Alaska	--------	--------	1	Ward Cove; T. H. Streets.
Lucia Island, Alaska	--------	2	--------	Near *ochraceus;* Albatross, 1894.
Tongass, Alaska	--------	--------	1	Nichols.
Naha Bay, Alaska	--------	3	--------	1 intermediate; Albatross, 1905.
Boundary Bay, British Columbia	--------	3	--------	Stanford Coll.; 1 aberrant, F. W. Weymouth, W. F. Thompson.
Union Bay, Bayne Sound, British Columbia	--------	3	--------	
Taylor Bay, Gabriola Inlet, British Columbia	3	3	--------	1 intermediate.
Departure Bay (Nanaimo), British Columbia.[1]	4	24	[1] 7	U.S.N.M. Coll.; Stanford Coll; Cal. Acad. Sci. Coll.; W. K. Fisher, W. F. Thompson; Albatross.
Port Renfrew, Straits Fuca, British Columbia	1	--------	--------	Stanford Coll., J. C. Brown.
Barclay Sound, Vancouver Island	4	--------	1	Albatross.
Port Ludlow, Wash	--------	--------	1	S. Bailey.
Orcas, San Juan Islands, Wash.[2]	2	5	3	Cal. Acad. Sci. Coll., Ida S. Oldroyd; *confertus* coarse spined, near *ochraceus*.
Friday Harbor, San Juan Islands, Wash	--------	5	--------	Cal. Acad. Sci. Coll., Ida S. Oldroyd; rather coarse spines.
Puget Sound (Simeahmoo)	1	[3] 1	1	Dr. C. B. Kennerly.
Puget Sound (near Tacoma)	--------	5	2	Frank Russell, Chas. M. Drake, F. W. Weymouth
Shoalwater Bay, Wash	1	--------	--------	Dr. J. G. Cooper, type of *fissispinus*.
Crescent City, Calif	5	--------	--------	Stanford Coll., J. O. Snyder.
Trinidad, Calif	4	--------	--------	Stanford Coll., F. W. Weymouth.
Humboldt Bay, Calif	1	--------	--------	Chas. M. Drake.
Drake's Bay, Calif	2	--------	--------	Albatross.
San Francisco Bay, Calif	4	--------	1	Dr. John Hornung.
San Francisco Bay (Sausalito)	--------	--------	1	Albatross; seine.
Farallone Islands, Calif	3	--------	--------	C. H. Townsend.
Santa Cruz, Calif	3	--------	--------	A. Forrer.
Monterey Bay (vicinity Point Pinos)	Many.	--------	Many.	Hopkins Marine Station.
Monterey Bay, station 3131	1	--------	--------	4 miles north of New Monterey, 48 fathoms, rocks; intermediate with *nodiferus*.
Point Sal, Calif	2	--------	--------	Carl Hubbs.

[1] At Departure Bay, where the Canadian Biological Laboratory is situated, the commonest forma is *confertus*. There are fewer, coarser spined specimens indistinguishable from *ochraceus*, and others, in which the spines form very prominent groups on the outer part of the ray, near *nodiferus*. 6 of the young examined are referable to *nodiferus;* 5 others are intermediate between *nodiferus* and *confertus*.

[2] The specimens from Orcas are difficult to classify by formae; with the exception of the acervate forma they are usually neither clearly *confertus* nor typical *ochraceus*.

[3] The type of *confertus*.

PISASTER OCHRACEUS SEGNIS Fisher

Plate 73, Figures 4, 8; Plate 75, Figure 6; Plate 84

Pisaster ochraecus segnis Fisher, Ann. Mag. Nat. Hist. ser. 9, vol. 17, 1926, p. 560, pl. 20, fig. 3.

Diagnosis.—Differing from typical *ochraceus* in having relatively few furcate straight pedicellariae and conspicuously larger crossed pedicellariae. Type, R. 143 mm., r 44 mm.; f. *nodiferus* (Venice, Calif.) R. 124 mm., r 35 mm.

Description.—This is the southern California representative of *Pisaster ochraceus* and it parallels exactly *Pisaster giganteus capitatus*, which also has larger crossed pedicellariae and much fewer furcate pedicellariae than its northern relative.

Both forma *ochraeeus* and *nodiferus* extend continuously to southern California, the latter apparently predominating at Laguna Beach, Orange County. The differences enumerated in the diagnosis apply to both formae.

The type of *segnis* corresponds to forma *ochraceus* but there is a tendency toward *nodiferus* in the arrangement of spines on the outer half of the ray. Exactly comparable specimens are common at Monterey. In general appearance there are no distinguishing features, until the small pedicellariae are closely scrutinized, when the scarcity of the furcate sort, so numerous in northern specimens, becomes apparent. The dentate stone-hammer pedicellariae are not very large, nor very numerous except proximally in the interradial channel. There are five or six actinal spines in a transverse series, in addition to the two inferomarginals.

All of the seven specimens from Laguna Beach are well developed forma *nodiferus* or perhaps more properly speaking the southern subforma of this. These specimens have large subglobular spines (pl. 75, fig. 6) in very convex groups, with wide generally spineless intervals between. Superficially there is little to distinguish them from the Tongass specimen of *nodiferus* which has unusually heavy tubercles. These southern *nodiferus* have heavier tubercles than Monterey specimens of forma *nodiferus*. They correspond to the heavier spined form of *Pisaster giganteus capitatus*. These dried specimens from Laguna Beach, as well as a similar one from Venice, Calif., have smaller clusters of "minor" pedicellariae than comparable examples from Monterey to Alaska, since in southern specimens the furcate pedicellariae, so important in northern examples, are rather scarce. On this account the spaces between the groups of spines appear less well armed, although the individual crossed pedicellariae are larger. This feature will distinguish the southern specimens from the Tongass example (pl. 82, fig. 1) which was unusually heavy tubercles. The stone-hammer pedicellariae are stouter than in the type specimen; about as in Plate 76, Figures 5, *5b;* occasionally even a little broader. Small, undifferentiated lanceolate pedicellariae are scarce.

Crossed pedicellariae: As in typical *ochraceus* there is a difference in size in the two formae. Type, length of well-developed ped. 0.35 to 0.36 mm.; *nodiferus*, Laguna Beach, 0.36 to 0.41 mm. (Pl. 73, fig. 4; compare with fig. 3, Tongass, Alaska, *nodiferus*.) Comparable specimens of forma *ochraceus* Monterey to Sitka, 0.25 to 0.27 mm.; forma *nodiferus*, 0.30 to 0.36 mm.

Furcate straight pedicellariae (pl. 73, figs. 8, 8*a*) have a diameter of about 0.28 or 0.29 mm. The form of the blade (type specimen) is rather nearer that of northern *nodiferus* than northern *ochraceus*. The undivided basal part of each jaw is relatively high, as in the northern race. Figure 7, same plate, is a blade from a specimen of forma *nodiferus*, Monterey. In *segnis* the upper edge of jaw blade varies in minor details, as evidenced by the two specimens figured.

Type.—No. E 1238, U.S.N.M.

Type locality.—Sixteen miles south of international boundary, Lower California.

Distribution.—From type locality to Santa Barbara, Calif., intergrading north of this point with typical *ochraceus*.

Specimens examined.—Fifteen.

Laguna Beach, Orange County, Calif., seven, forma *nodiferus*. Prof. W. A. Hilton.

Venice, Los Angeles County, Calif., one, forma *ochraceus*, one forma *nodiferus*. Prof. A. B. Ulrey.

Lower California, 16 miles south of international boundary, six forma *ochraceus* and *ochraceus-nodiferus*. E. F. Ricketts.

Remarks.—It is interesing to note that in the southern extension of their ranges both *ochraceus* and *giganteus* run to heavier spines, larger and often fewer crossed pedicellariae, and much fewer furcate pedicellariae.

Mr. Paul O. Greeley observed that on the ocean side of the Government breakwater at San Pedro, Calif., *segnis* predominated to the extent of about 80 per cent while on the harbor side *P. giganteus capitatus* was the more abundant, there being only 1 or 2 *segnis* to 50 *capitatus* (November, 1925).

PISASTER GIGANTEUS (Stimpson)

Plate 73, Figures 5, 5*a*, 5*b*; Plate 74, Figures 3, 3*a*–3*c*; Plate 77, Figures 1, 2, 2*a*, 2*b*, 3, 3*a*–3*c*, 5, 6, 6*a*–6*d*, 7, 7*a*; Plate 78, Figures 5, 5*a*, 5*b*; Plate 83, Figure 2; Plate 85, Figure 2; Plate 86, Figure 11; Plate 87

Asterias gigantea Stimpson, Boston Journ. Nat. Hist., vol. 6, 1857, p. 528, pl. 23, figs. 4, 5, 6 (Tomales Bay, Calif.).—Verrill, Trans. Conn. Acad., vol. 1, 1867, p. 327.

Asterias lütkenii Stimpson, Proc. Boston Soc. Nat. Hist., vol. 8, 1862, p. 265 (California or Oregon).—Verrill, 1867, p. 32.—Perrier, Rév. Stell., 1875, p. 70.—Bell, Proc. Zool. Soc., London, 1881, p. 495.—Sladen, Challenger Asteroidea, 1889, pp. 566, 824.—De Loriol, Mém. soc. phys. et hist. nat. Genéve, vol. 32, 1897, p. 15, pl. 2 [17], figs. 1–1*h* (Vancouver Island).

Asterias exquisita de Loriol, Recueil Zool. Suisse, vol. 4, 1887, p. 403, pl. 18, fig. 2 (young specimen, Santa Cruz, Calif.).

Calliasterias exquisita Fewkes, Zoological Excursions. 1. New Invertebrata from the Coast of California, Bull. Essex Inst., vol. 21, 1889, p. 33.

P[isaster] lütkenii Verrill, Amer. Journ. Sci., vol. 28, 1909, p. 63; Amer. Nat., vol. 43, 1909, p. 543.

Pisaster lütkenii Fisher, Smithsonian Misc. Coll., vol. 52, 1908, p. 89.—Verrill, Shallow-water Starfishes, 1914, p. 83, pl. 40, figs. 1, 2.

Pisaster lütkenii var. *australis* Verrill, Shallow-water Starfishes, 1914, p. 88 (off Pacific Grove, Calif., not San Diego).

P[isaster] giganteus Verrill, Amer. Journ. Sci., vol. 28, 1909, p. 63.

Pisaster giganteus Verrill, Amer. Nat., vol. 43, 1909, p. 545; Shallow-water Starfishes, 1914, p. 89, pl. 37, figs. 1, 2.—Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 17, 1926, p. 561, pl. 19, figs. 2, 2*a*, 2*b*; pl. 21, figs. 1, 2.

Diagnosis.—Rays five or six; size sometimes very large with R over 300 mm. A typical *Pisaster*, differing from *ochraceus* in having less numerous and longer, solitary, terminally swollen, subconic to subglobose coarsely striated spines, rather uniformly spaced over the abactinal surface, never in close ranked lines forming a recticulate pattern, nor in acervate heaps; base of spine surrounded by a zone of bare skin, blue in life, fringed by numerous crossed and furcate pedicellariae; stone-hammer-shaped, large pedicellariae abundant to scarce. The giant type measures R about 304 mm., r 73 mm., R = 4.1 r. A characteristic intertidal example from Monterey measures R 123 mm., r 30 mm., R = 4.1 r; breadth of ray at base, 31 to 33 mm. Disk rather high; ray, subcylindrical in section, slightly flattened actinally, and capable of slight inflation at base.

Description.—The abactinal spines are numerous, solitary, spaced, with swollen coarsely striated or furrowed, subconical or acorn-shaped ends. (Pl. 77, figs. 2, 3.) Each stands on a prominence of its plate, in the middle of a subcircular disk of bare integument (blue in life) which is fringed with a usually thick cordon of crossed and furcate pedicellariae. This blue sheath can rise nearly to the end of the spines, which are white, or can be retracted to their bases. The spines do not typically form either transverse or longiseries but stand irregularly. In some examples the carinal series can be traced with ease. One can count across the ray at base 10 to 15 spines in a zigzag way (or upward of 25 in big specimens). Small examples are found, however, with only about five irregular longiseries and these are easily mistaken for *capitatus*.

There are really two extremes of formae with even more numerous intergrades. One has heavier, more widely spaced, less numerous abactinal spines. (Pl. 87, fig. 2.) The spines are usually more obtuse or subglobose terminally and it is this type which sometimes predominates in *capitatus*, at the south. The other, or typical form (pl. 87, fig. 1; pl. 85, fig. 2) has numerous slenderer spines with more elongate, swollen tips, acorn-shape, subglobose, obtuse, conical or even subcylindrical. Their coarse longitudinal furrows give them the appearance of tiny drills, and they vary widely in form even in the same ray.

The spaces between the collars of pedicellariae are filled with the clusters of delicate papulae which, when expanded, arise from swellings of thin integument above the skeletal intervals. On the actinal surface the papulae are long and fill the spaces between the spines. The bases of the papulae are armed with very tiny lanceolate straight pedicellariae. (Pl. 77, fig. 5.)

Superomarginal series situated low on side of ray, often irregular proximally. The spines, one to a plate, are very similar to the superadjacent abactinals. Intermarginal channel well-marked.

Inferomarginal spines two to a plate (occasionally three in big specimens), clavate, longitudinally striate, the tip sometimes obliquely beveled, or near the base of ray, irregularly eroded, sulcate, or pitted. Most of the spines, as well as the similar actinals, may have a sulcus on the external side, but this is sometimes lacking. (Pl. 77, fig. 1.)

Actinal spines normally one to a plate, similar to the inferomarginals, but those of the adjacent row often a little thicker and longer; those of the innermost row generally slenderer. The spines are longitudinally channeled or striated, the furrows varying in depth. They are less evident in the type than in some large examples from Monterey. There are ordinarily three or four longiseries of actinal spines in the common medium-sized examples found in tide pools. Two specimens of the heavier-spined form with R 55 and 80 mm. have two series. A large specimen of the typical form from Monterey (R 215 mm.) has three, while one with R only 120 mm. has four. The type (Tomales Bay) has six actinal spines in a transverse series on the broadest part of ray and four at the middle. These actinals are clavate with usually a sulcus on the external face. Verrill (1914, p. 87) mentions a specimen of "*lütkenii*" from off Monterey having R 284 mm., in which

> The proximal inferomarginal and most of the actinal plates bear two, three, or even more, stout, often divergent spines, so that one can count eight to ten of these spines on each irregular transverse series. But one ray (doubtless a reproduced one) is only about two-thirds as long as the rest, though nearly as stout; on this the ventral spines form only four or five rows, though similar in size. On the distal half of all the rays the ventral rows decrease to about four to six, the plates bearing only two spines, or but one.

Adambulacral spines, similar to those of *ochraceus*, in a single close series. In the typical form the spines are slender, very slightly flattened and tapered, or mixed tapered and untapered, round-tipped (blunt) with or without a depression at the tip suggesting an incipient groove. In the larger-spined form the spines are more evidently flattened with a slight groove on the outer side toward the tip. On the narrow adoral carina the spines usually lengthen, become slenderer, and near the mouth plates stand single file. On the ray the adambulacral spines stand very close to the inner series of actinals, to which they are about equal in length.

The mouth plates have the usual *Pisaster* armature of a longer, usually tapering, subacute, blunt, or subtruncate actinostomial spine, with a very short lateral companion; and a prominent, tapered suboral, somewhat stouter than the innermost adambulacrals. The Monterey specimens present numerous variations in the relative size and shape of the spines.

Madreporic body large, exposed, situated less than one-half r from center of disk; striae fine, irregular.

Crossed pedicellariae (pl. 73, figs. 5, 5*a*) are smaller than those of *capitatus* and typically more numerous. The majority occur in the circumspinal wreaths of the abactinal and inferomarginal spines and in the external clusters of the inferomarginals and actinals, but occasionally small clusters of them are found between the dorsal spines, though not so commonly as in *ochraceus*. The pedicellariae of both large and medium-sized specimens from Monterey Bay measure 0.27 to 0.31 mm. in length, while those of the type (which is very large) vary from 0.27 to 0.34 mm., with a few as large as 0.4 mm.

Straight pedicellariae: (*a*) Very small broadly lanceolate pedicellariae (pl. 73, fig. 5*b*) about 0.15 mm. long are abundant on the thin integument of the papular swellings and on the bases of the papulae themselves. Similar ones form conspicuous pedunculate clusters or festoons here and there along the furrow face of the adambulacrals, usually at the base of a conspicuous, often quite large, toothed pedicellaria. The small ones are 0.15 to 0.2 mm. long and the large one about 1.5 mm., sometimes smaller or larger.

(*b*) The bilaminate furcate pedicellariae (pl. 74, figs. 3, 3*a*–3*c*) are abundant abactinally, brigaded with the crossed. They are not so plentiful on the actinal spines. An average one measures 0.21 mm. broad by 0.2 high. They are smaller than those of *ochraceus* and differ in form.

(*c*) The stone-hammer-shaped denticulate pedicellariae are very variable in size and shape, and are similar to those of *capitatus*. (Pl. 77, figs. 6, 6*a*–6*d*). They are sometimes abundant abactinally, but again may be practically absent, except from the proximal part of the intermarginal channel and among the actinal spines. The largest (1.6 mm. long) are found in the actinal interradial channel. The jaw varies from broadly lanceolate to broadly oval and the number of teeth from four to eight. This type of pedicellaria appears to be too variable to be of use in distinguishing species although there are *average* differences.

Color in life: Abactinal spines white, surrounded by a conspicuous zone of bright to dull blue integument; general tint brown, the papular areas raw Sienna; actinal surface including inferomarginal spines, yellowish white with pale grayish green papulae; tube feet Capucine buff. Young specimen: General tint cinnamon, with spots of reddish brown between the collars of pedicellariae; spines pale pink, violet, and blue; zone of blue skin surrounding spine pale blue. Another variety, tawny olive mottled with snuff brown or sepia.

Variations.—The type specimen has six rays and was dried without first being hardened so that the abactinal surface has collapsed. It is a veritable giant, the radii being 304 and 73 mm. The abactinal spines are very numerous, fairly equidistantly spaced, and the swollen end is elongate, tapered and slightly swollen at the rounded tip. (Pl. 77, figs, 2, 2*a*, 2*b*.) The large denticulate "stone-hammer" pedicellariae are very numerous abactinally and are exactly like those of Monterey specimens. As mentioned above, there are six actinal plus two inferomarginal spines in a transverse series on the broadest part of the ray; on the middle 4+2; one series of actinals reaches to within two or three inferomarginal plates of the terminal shield. The inferomarginals carry two spines throughout the series.

At Monterey giant specimens of both the slenderer and heavier spined formae occur, usually offshore or on the piles of wharves. They have never been taken in tide pools. Occasionally a 6-rayed specimen is met with. In the giant specimens of the heavier-spined form, the abactinal spines are rather more widely spaced, are sometimes quite unequal, and the end is more subglobose than conical. Scarcely two examples of these "overfed" individuals are alike. Verrill has noted a specimen with an extraordinary development of actinal spines (1914, p. 87).

The medium-sized specimens occasionally found in tide pools at Monterey Bay are also very variable in respect to the size, shape, and spacing of the spines and in the number of "stone-hammer" pedicellariae present, as indicated in the description. It is probable that the form with fewer, heavier spines has become dominant in the southern part of California; or conversely, what is known as the race *capitatus* has developed from this sparsely spined forma of *giganteus*.

Two specimens rather below medium size, from 48 fathoms, off Monterey (station 3131), vary nearly as widely in respect to robustness of spines as do ordinary intertidal examples. Both have very numerous "stone-hammer" pedicellariae.

Verrill (1914, p. 88) introduces a new variety from San Diego—*Pisaster lütkenii* var. *australis*. The description does not state the differences which separate the variety from typical *lütkenii* (that is, *giganteus*) but simply lists the characters of a large specimen supposed to have been collected by Dr. Edward Palmer. This specimen, which I have examined, bears the number 4029 and also a very small label pasted on, with "W. R. Coe, 1901." Doctor Coe tells me that he believes this specimen to be one of several large ones which he collected at Pacific Grove, Monterey Bay, in 1901. The loose label with "San Diego, Dr. Edward Palmer" by an unfortunate circumstance became associated with this Monterey specimen. The type of var. *australis* is therefore from Monterey Bay and represents simply an individual variant.

Young.—Small specimens resemble *capitatus* in having few, relatively large, abactinal spines. A specimen with R 27 mm. has a zigzag longiseries of dorsolateral spines and a very irregular series of carinals. The stone-hammer pedicellariae are numerous and thicker than the spine-tips in most cases. (Pl. 86, fig. 11.) The superomarginal plates have a conspicuous area of hyaline bosses. Crossed and furcate pedicellariae, numerous. Monterey.

Anatomical notes.—The skeleton is essentially like that of *ochraceus*, a very irregular reticulum of higher spiniferous ridges inclosing spaces subdivided by lower, spineless trabeculae into the irregularly circular or oval papular areas (skeletal intervals). The vertical intermarginal pillars between the supero and infero marginal plates appear to be like those of *ochraceus*. These increase in size with age. At first, in young specimens, there is simply a single ossicle tying the supero and infero marginal plates. Secondary marginal and actinal plates develop with growth. As the animal grows older the general skeleton is strengthened by the addition of elongate ossicles on the coelomic surface, especially in the form of buttresses on the sides of the ray, and across the actinal area, between the supero marginals and lower end of the ambulacral plates. These actinal buttresses, composed of numerous small ossicles, separate a series of rather deep pits all along the ray, at the outer end of the ambulacral plates. The older the specimen the deeper the pits. Through these extensions of the coelom the fluid of the body cavity reaches the extensive system of actinal papulae.

The ambulacral ossicles are very compressed and thin. The furrow broadens at the base to narrow quickly toward the small actinostome. At the widest part there are eight longiseries of tube feet in well-developed specimens.

The actinostome is only about one-fourth r in diameter and is characteristically sunken so that it lies close to the abactinal body wall. The animal everts its stomach when eating. It is the large very numerous and powerful proximal tube feet which open mussel shells, or lift barnacles and limpets from rocks. The long adoral carina is much narrower at the inner end than the oral plates. Occasionally plates of one side of carina are overdeveloped so that the median suture lies on the side of the carina, or follows a rather sinuous course.

Type.—No. 1283, U.S.N.M.

Type locality.—Tomales Bay, Calif.; Mr. Samuels.

Distribution.—Southern part of Vancouver Island to Monterey Bay, intergrading to the south with *P. giganteus capitatus*. Low tide to 48 fathoms (Monterey Bay).

Specimens examined.—Very numerous examples from Monterey Bay, Calif.

Station 3131, Monterey Bay, Calif., 36° 41′ 30″ N., 124° 54′ 10″ W., 48 fathoms, mud, rocks, two specimens.

The type of *Asterias lütkenii*, "California or Oregon."

The type of *Asterias gigantea*.

Remarks.—This species is very distinct from both *ochraceus* and *brevispinus* and can be recognized by its usually brown or purplish-brown color and evenly distributed, whitish, dorsal spines surrounded by a zone of blue skin, often very vivid in luster.

It is regrettable that the name *giganteus* falls to this beautiful species by the fortunes of nomenclature, since the common tide-pool form is by no means gigantic for the genus. In favorable localities, however, the species does reach a large size, as evidenced by the type with R 304 mm., and by specimens caught offshore in Monterey Bay.

I have not examined specimens from north of California unless the type of *lütkenii* is from Oregon. Verrill records a specimen from Vancouver Island (Canadian Geological Survey) and de Loriol one from Saanich Inlet, north of Victoria on the east side of Vancouver Island. De Loriol's figure [27] shows a specimen with very small, tapered, usually not capitate spines, with occasionally two or three on the dorsolaterial plates and usually two or three on the carinals. This specimen may represent a forma comparable to *confertus* in *ochraceus*. It certainly is not typical *giganteus*.

PISASTER GIGANTEUS CAPITATUS (Stimpson)

Plate 73, Figures 6, 6*a*; Plate 77, Figures 4, 4*a*; Plate 85, Figure 3; Plate 88

Asterias capitata Stimpson, Proc. Boston Soc. Nat. Hist., vol. 8, 1862, p. 264.—Verrill, Trans. Conn. Acad. Sci., vol. 1, 1867, p. 327.—Perrier, Rév. Stell., 1875, p. 71.—Sladen, Challenger Asteroidea, 1889, p. 566, 820.

P [*isaster*] *capitatus* Verrill, Amer. Journ. Sci., vol. 28, 1909, p. 63.

Pisaster capitatus C. F. Baker, First Annual Report of Laguna Marine Laboratory (1912), p. 89.—Verrill, Shallow-water Starfishes, 1914, p. 81, pl. 36, figs. 3, 4; pl. 56, fig. 4.

Pisaster giganteus capitatus Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 17, 1926, p. 562.

Diagnosis.—Differing from *Pisaster giganteus* in having typically fewer and generally stouter abactinal spines, larger crossed pedicellariae, and very few furcate bilaminate straight pedicellariae. Rays five, rarely six. R 190 mm., r 52 mm.; rays inflated, abactinal spines stout, widely spaced, subconical; larger circumspinal collars 8 to 10 mm. broad. Narrower-rayed form (Venice, Calif.), R 170 mm., r 40 mm., width of circumspinal collars, 5 mm.

Description.—The two formae of *P. giganteus* extend into southern California and are thus included in the race *capitatus*. The somewhat heavier spined form (to which the type belongs) has even fewer spines than its northern equivalent but there are scarcely two specimens alike. One from San Diego with R 140 mm. has only two dorsolateral series of spines irregularly aligned (about five longiseries between the superomarginals, while a specimen from Laguna Beach (R 180 mm.) has the equivalent of nine series without serial alignment. The spines are widely spaced with broad collars of bare skin fringed by a circular ruff of crossed pedicellariae. The space between the spines may reach 10 or 12 mm. The spines are strongly capitate, robust, with ornately grooved, subglobular to acorn-shaped ends, and are seated rigidly on convex plates of the very irregular skeleton. The dorsolaterals are sometimes heavier than the carinals and superomarginals, sometimes subequal to them. (Pl. 77, fig. 4.) In between the spines are conspicuous clusters of papulae guarded by small lanceolate pedicellariae, attached to the papulae, and in most cases by few to many much larger stone-hammer denticulate straight pedicellariae similar to those of *giganteus*. There are very few isolated clusters of crossed and furcate pedicellariae among the papulae.

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[27] Mém. soc. phys. et hist. nat. Genève, vol. 32, 1897, pl. 2, fig. 1.

The other extreme has narrower rays and more numerous, generally slenderer sometimes quite unequal abactinal spines. There is little to distinguish it from some specimens of true *giganteus* (with which Verrill confused it) except the characters of the pedicellariae enumerated in the diagnosis. One may count from 9 to 15 spines across the ray between the two superomarginal series, but there is never regular serial alignment. The collar of blue skin around each spine is generally narrower than in the type forma. The usually slenderer rays cause the spines to be less widely spaced. There is complete intergradation between the two formae in a good series of large specimens from Venice, Calif., contributed by Prof. A. B. Ulrey. The Laguna Beach specimens are all the type form.

The superomarginal spines are similar to the dorsals, but generally more numerous than the outer dorsolaterals, and form a straight series, low on the side of ray. A specimen from San Diego has 23 superomarginal spines corresponding to 47 inferomarginal plates.

Inferomarginal spines smaller than the superomarginals, two to a plate, subclavate, finely grooved and with a well marked, external, often deep sulcus. There are usually two or three longiseries of actinal spines similar and subequal to the inferomarginals, sometimes a little heavier on the proximal part of the ray. They all carry external clusters of crossed pedicellariae. As in typical *giganteus* certain specimens, on some of the inferomarginal and actinal plates of the proximal half of ray have two to four spines, greatly increasing the spine count and destroying any regular alignment. Such a specimen may have 8 or 10 spines in an irregular transverse series.

Adambulacral spines slender, flattened, subtruncate or blunt, slightly tapered or not, sometimes with a shallow groove on the outer half, deepening toward the tip (Laguna Beach). In such a specimen the spines range from slightly tapered, blunt, to slightly spatulate. The adoral carina is very narrow, composed of about 10 or 12 pairs of plates, and back of the mouth plates the first two or three pairs of plates have the spines in single file (some of the spines being suppressed).

Each mouth plate has two actinostomial spines (the latter quite small) and one suboral, tapered and pointed, similar to but often stouter than the adjacent adambulacral spines.

Crossed pedicellariae in circumspinal wreaths abactinally and in clusters on outer side of inferomarginal and actinal spines. They are less numerous than in typical *giganteus* which sometimes has clusters between the spines. Pedicellariae average larger than in *giganteus;* length 0.5 to 0.46 mm. (Laguna Beach; San Diego; Lower California). (Compare pl. 73, figs. 5 and 6.) In form they adhere closely to the generic type and are very little different from those of *giganteus*. Note relative length of side of terminal lip. In Lower Californian specimens there are fewer teeth in the median vertical series of the shank of jaw.

Straight pedicellariae: (*a*) There are a few to numerous tiny lanceloate dermal pedicellariae, similar to those of *giganteus*, guarding the papulae (actinal and abactinal). Along the furrow face of the adambulacrals are pedunculate clusters, here and there, of very small lanceolate pedicellariae, usually at the base of a large toothed one (as in *giganteus*).

(*b*) Small furcate pedicellariae, so numerous in *giganteus*, are relatively few and occur with the crossed; diameter 0.225 mm. (Pl. 73, fig. 6*a*.)

(*c*) Heavy subconical "stone-hammer" pedicellariae with small terminal teeth vary greatly in number and present no constant differences from those of *giganteus*. When almost absent from the abactinal surface they may be found intermarginally and in the interbrachial channel. The jaws are likely to be broader in the thicker spined specimens.

Madreporic body subcircular, conspicuous, less than one-half r from center of disk; striae fine, irregular.

Young.—Two young specimens from Laguna Beach, Orange County, Calif., measure R 16 and 24 mm. Each has a single series of well spaced dorsolateral spines and a single series of actinals. In the smaller there are two pairs of contiguous adambulacrals behind the mouth plates; in the larger, four. (Pl. 85, fig. 3.)

In contrast to *giganteus* of approximately the same size, the abactinal spines are fewer and more widely spaced while the furcate pedicellariae are very scarce; in *giganteus* these are abundant.

The skeleton of the smaller specimen is constructed essentially as that of young *ochraceus*, but shows larger areas of hyaline beads on the superomarginal plates, which are practically covered. They are also on the primary dorsolaterals and carinals (absent in *ochraceus*).

Type.—No. 1280, U.S.N.M.; Dr. J. S. Newberry.

Type locality.—San Luis Obispo Bay, Calif.

Distribution.—Northern Lower California to San Luis Obispo Bay, Calif.; intertidal and shallow water.

Specimens examined.—Twenty-eight.

Specimens of Pisaster giganteus capitatus examined

Locality	Number of specimens	Remarks
San Luis Obispo Bay, Calif.	Type.	Dr. J. S. Newberry.
Santa Barbara, Calif.	2	D. S. Jordan, 1880.
Venice, Los Angeles County, Calif.	12	A. B. Ulrey, Stanford Coll.
Laguna Beach, Orange County, Calif.	5	W. A. Hilton, C. F. Baker, Stanford Coll.
Lower California (16 miles south of international boundary)	4	E. F. Ricketts.
San Diego, Calif.	3	E. C. Starks, Stanford Coll.
La Jolla, Calif.	1	39888, U.S.N.M.

Remarks.—By a curious mistake the type locality is stated by Stimpson to be "San Diego, Calif., Colorado expedition, Dr. J. S. Newberry." The type specimen is No. 1280, U.S.N.M., and is labeled in Doctor Stimpson's well-known handwriting "*Asterias capitata*, Stm., San Luis Obispo, Doctor Newberry." This specimen is really intermediate between *capitatus* and *giganteus*, as the locality would lead one to infer. It has not the characters of the race *capitatus* developed to the extreme degree that one would wish to see in a "type" and it is very unfortunate that the type specimen is not from San Diego, or from some locality well south of Point Conception.

Dr. Mary J. Rathbun, in this connection, showed me documentary evidence that Doctor Newberry did not collect at San Diego. In 1883, Dr. Richard Rathbun published the following in Descriptive Catalogue of the Collection Illustrating the Scientific Investigation of the Sea and Fresh Waters (Great International Fisheries Exhibition, London, 1883, U. S. America), page 12:

> Explorations and surveys west of the one hundredth meridian, under the direction of Gen. A. A. Humphreys, Chief of Engineers, by Lieut. George M. Wheeler in charge, from 1872–1879. The naturalists of this survey were Dr. H. C. Yarrow, Mr. H. W. Henshaw, Professor Newberry, Mr. Charles E. Aiken, Dr. J. T. Rothrock, and Oscar Loew, and their field operations included the fresh-water lakes and rivers of Utah, Colorado, New Mexico, Arizona, and western and southwestern Nevada, Salt Lake, Utah Lake, and other salt-water lakes, and the Pacific coast in the vicinity of Santa Barbara, Calif.

The type has R 81 mm., r 21 to 23 mm. The abactinal spines are of the large, capitate, well-spaced sort characteristic of *capitatus* from further south, but the crossed pedicellariae are too small and the furcate pedicellariae are too numerous. The larger crossed pedicellariae measure 0.36 mm. in length while the Laguna Beach and San Diego examples measure 0.4 and 0.45 mm. (*giganteus*, 0.26 to 0.31 mm.). The smaller pedicellariae of the type measure 0.31 mm. in length. The furcate pedicellariae are not so numerous as in typical *giganteus*, but are not so scarce as in the extreme form of *capitatus*.

Although the type of *capitatus* is frankly an intermediate it is superficially more like the southern than the northern race.

The record of *capitatus* from Monterey Bay appears to be based on the form of *giganteus* having unusually stout, well spaced spines. I have a young specimen which might pass for *capitatus* but it has abundant furcate and small crossed pedicellariae.

PISASTER BREVISPINUS (Stimpson)

Plate 74, Figures 4, 4*a*–4*e;* Plate 76, Figure 8; Plate 78, Figures 1–4; Plate 79, Figures 2–5; Plate 86, Figures 12–16; Plates 89–93

Asterias brevispina Stimpson, Boston Journ. Nat. Hist., vol. 6, 1857, p. 528, pl. 23, fig. 3 (San Francisco Bay, Calif).

Asterias paucispina Stimpson, Proc. Boston Soc. Nat. Hist., vol. 8, 1862, p. 266 (Puget Sound).—Perrier, Rév. Stell., 1875, p. 60.

Asterias (*Pisaster*) *papulosa* Verrill, Amer. Journ. Sci., vol. 28, July, 1909, p. 63 (Puget Sound).

P[*isaster*] *brevispina* Verrill, Amer. Journ. Sci., vol. 28, 1909, p. 63.

Pisaster brevispinus Verrill, Shallow-water Starfishes, 1914, p. 77, pl. 41, figs. 1, 2; pl. 44, figs. 1, 2; pl. 45, fig. 1; pl. 69, fig. 3; pl. 76, figs. 1–1*b*.

Pisaster papulosus Verrill, Shallow-water Starfishes, 1914, p. 91, pl. 42, fig. 1; pl. 43, fig. 1; pl. 60, fig. 1; pl. 76, figs. 2–2*d*; pl. 80, fig. 4.

Pisaster ? paucispinus Verrill, Shallow-water Starfishes, 1914, p. 98, pl. 36, figs. 1, 2.

Diagnosis.—Differing from *P. ochraceus* in its rose-pink coloration, variegated with gray-green or maroon-purple papular areas; dorsolateral spines not forming a reticulated pattern (except occasionally in forma *brevispinus*) but standing singly or in small groups, often few in number; furcate pedicellariae of characteristic form, with upper margin of jaw smooth, not crenulate. Rays five. A giant specimen of forma *brevispinus* (pl. 90, fig. 2), R 320 mm., r 66 mm.; one of forma *paucispinus* (Verrill's *papulosus*) R 315 mm., r 60 mm. This species is one of the largest starfishes known.

Description.—The most obvious variation in this species is in the abundance of abactinal spines. There is a complete series of intergrades between the extremes. It is convenient to recognize two formae equivalent to the old species *brevispinus* and *paucispinus*. Each of these is divisible into several subformae; but in view of the fact that there are about as many intergrades as representatives of the subformae no service is rendered by recognizing them formally by name.

The species *brevispinus* is easily distinguished in life from its congeners by its light rose-pink color, mottled with the gray-green or maroon papular areas. This color is rather striking and no variation of *ochraceus* or *giganteus* approaches it. Moreover, the pink color varying in intensity and shade is relatively constant, as compared to the wide range in *ochraceus* from yellow ochre to purple.

Forma BREVISPINUS (Stimpson)

Plate 74, Figures 4*c*, 4*d*; Plate 76, Figure 8; Plate 78, Figures 1, 2, 2*a*, 2*b*, 4, 4*a*, 4*b*; Plate 79, Figures 2, 2*a*, 2*b*, 3*c*, 4; Plate 89; Plate 90, Figures 1, 2; Plate 91, Figure 1; Plate 92; Plate 93, Figure 4

To this forma belong those individuals having dorsolateral spines typically in small groups or clusters, which are spaced without regular order between the carinals and the superomarginals. There is great variation in the number of spines per group as well as in the number of groups. In extremes such as Plate 89, Figures 1 and 2, there are 3 or 4 to 8 or even 10 capitate spines per group, sometimes arranged in short transverse series. The groups are somewhat acervate (pl. 89, fig. 2; pl. 90, fig. 2), especially on the outer part of the ray. In these extremes the carinal spines are crowded in transverse groups on the plates so as to form a conspicuous radial band. The primary apical plates of the disk are similarly heavily armed, the spines forming a rude star. These accentuated forms of *brevispinus* have been taken at Puget Sound, Wash.; Crescent City, Bolinas, and Monterey Bay, Calif.

The less pronounced phase of *brevispinus* is shown on Plate 92. Figure 1 is comparable to Stimpson's type (see Verrill, pl. 41) from San Francisco Bay. In these, the dorsolateral spines stand singly or in small groups of two to five. They are slenderer and the end is frequently subconical with a subacute or rounded tip. The carinal spines are one to three to a plate. In some specimens there is but a single series of carinal spines while in others, not materially different as to dorsolateral armature, the spines are two or three ranked on the proximal carinals or on nearly all.

In some specimens of the less spinous subforma the abactinal spines are slender, tapered, subacute, without, or with only a slightly swollen, subcapitate tip. They stand usually singly on their plates and their collars of pedicellariae are generally conspicuous. Plate 92, Figure 2, represents a specimen intermediate between Figure 1 and this weak-spined variant (Monterey Bay). The giant specimen (pl. 91) has tapered pointed spines and belongs on the border of *brevispinus*, as does Plate 93, Figure 4. The latter has fewer and slightly stouter spines than specimen Plate 92, Figure 1, and is an intermediate between the well-developed phase of *brevispinus* and *paucispinus*. The loss of the adradial series of spines would transform this specimen into one of forma *paucispinus*. This remark is true of the great specimen, Plate 91. Compare it with Plate 90, Figure 2, a representative of the heavier spined subforma. Both are from San Juan Islands, Wash.

Superomarginal spines, one to three to a plate, are not of much value for diagnostic purposes. The number varies on different rays of the same specimen. Specimen, Plate 89, Figure 1, has two (sometimes one) on plates of proximal two-thirds of ray and one on the distal third; Figure 2, the same; Plate 90, Figure 2, giant specimen, has three sometimes with a small fourth, at base of ray, then two or three, and finally one near tip; Plate 91, figure 1, giant specimen, two proximally and one distally; Plate 92, Figure 1, irregularly two or one on a few proximal plates and one on rest of series. Superomarginals are similar in size and form to the abactinals but in some specimens are slightly gouge-shaped on outer side of tip.

The inferomarginal and actinal spines are characteristic of the genus and present no especial peculiarities. There are two clavate to subspatulate, usually externally furrowed, inferomarginals, followed in a transverse series by three or four similar actinals, all much stouter than the superomarginals. In well-developed specimens the two outer actinals are generally a little larger than the inferomarginals. There is considerable variation in the form of the spines and their robustness. In very large specimens proximally the tips become flattened as if pinched while soft. A shallow sulcus is normally present on the outer side in most of the specimens. (Pl. 78, fig. 1.)

Adambulacral spines slender, slightly tapered, round-tipped, forming a single crowded series. Here and there a spine is squeezed a little in advance of its neighbors on the furrow edge. Where the series bends upward toward the actinostome the spines gradually lengthen and thicken, on the approach to the adoral carina, upon which they are generally conspicuously stouter and longer. This carina is unusually well developed and in mature specimens is composed of 12 to 15 pairs of conjoined plates. (Pl. 79, fig. 2*a*.) It curves upward to the actinostome, which is sometimes quite close to the dorsal wall of the well-arched disk. The first few plates of the carina lack spines, although these same plates are spiniferous in young specimens. In fully adult specimens the first adambulacral plate is conspicuously shorter than the second; in young specimens they are subequal to or larger than the following plates.

The mouth plates widen with age and sometimes become somewhat distorted. They are, as is usual in *Pisaster*, considerably broader than the narrow neck of the adoral carina but there is little specifically characteristic. Ordinarily there are two unequal flattened blunt marginal (actinostomial) spines and a longer and stouter, variously formed, but usually tapered and blunt suboral spine, not in the same position on companion plates, owing to crowding.

Papulae abundant, grayish green in life, arising from various sized hernialike elevations of thin integument carrying numerous very small broadly lanceolate pedicellariae, which also occur on the base of the papulae themselves. These clusters are of unequal size, some containing a large number of papulae and they are closely spaced among the spines. Actinal areas each with few, very long papulae, very numerous and conspicuous in the aggregate.

Crossed pedicellariae (pl. 79, figs. 2*b*, 4) of the usual *Pisaster* type are fairly abundant, mixed with the furcate type, in circumspinal wreaths and in numerous small clusters, independent of spines, among the papulae. They occur also in clusters on the outer side of the inferomarginal and actinal spines. Abactinal pedicellariae from a giant specimen (pl. 90, fig. 2) measure 0.24 to 0.27 mm. in length (San Juan Islands, Wash.), while on a large Monterey specimen (pl. 89, fig. 2) they measure 0.31 mm. Actinal and inferomarginal pedicellariae are larger (0.35 mm.).

Straight pedicellariae: (*a*) The *Pisaster* bifid furcate pedicellariae are characteristic in form (pl. 74, figs. 4*c*, 4*d*) and differ from those of *ochraceus* and *giganteus* in having the shorter blade of the jaw in a rudimentary form. The larger blade is more like that of giganteus but is uniformly larger. Its upper border is smooth, not scalloped as in *ochraceus*. The pedicellariae have a diameter of 0.27 to 0.32 mm. and are remarkably uniform in size, irrespective of size of specimen and locality. They have the usual distribution and in some specimens outnumber the crossed pedicellariae abactinally, especially on the clusters between the spines.

(*b*) Very small, broadly lanceolate pedicellariae are usually abundant abactinally as well as actinally, especially on and around the bases of papulae. Actinally they are frequently of more diverse and larger sizes. Very similar ones form conspicuous pedunculate clusters on the furrow surface or margin of the adambulacrals. These clusters, or sometimes long festoons, generally carry one or several very large, terminally toothed pedicellariae, about which the smaller ones cluster in masses. (Pl. 76, fig. 8; pl. 78, figs. 2, 4.)

Large dentate pedicellariae of numerous sizes up to 2.5 mm. (exceptionally 4 mm.) long are sometimes very abundant. (San Juan Islands, pl. 90, fig. 2.) There is such wide variation in form (the jaws varying from a tapered form with narrow tip and few teeth (pl. 78, figs. 3, 4, 4*a*–4*b*) to a broad rounded end and 6 or 8, exceptionally 10 or 12, teeth (pl. 78, fig. 2*a*) that it is difficult to find features of precise diagnostic value. The shape varies widely on the same specimen, being generally longer and slenderer actinally (fig. 3*d*), where the longest occur in the axillary channel. Specimens occur in which there are few abactinal dentate pedicellariae. The relative development of spines has no relation to the abundance of pedicellariae or vice versa. The large specimen from Lopez Island, San Juan Islands (pl. 90, fig. 2), has a most extraordinary equipment of this type of pedicellariae, the other sorts being very numerous but less conspicuous (pl. 78, figs. 2*a*, 2*b*). Among the examples of forma *paucispinus* are two from Nanaimo having a minimum of spine development and the abactinal surface armed with a multitude of these "major" pedicellariae which are more conspicuous than the spines. (Pl. 91, fig. 2; pl. 78, figs. 3, 3*a*–3*d*.)

The madreporic body is large, subcircular, and situated about one-third r from center of disk.

Color in life: Rose pink, the papular areas dark sage green or maroon purple. Some specimens are brighter or more intense pink than others. Those with purplish papular areas are more striking than those with the more prevalent greenish areas.

Forma PAUCISPINUS (Stimpson)

Plate 74, Figures 4, 4*a*, 4*b*, 4*e;* Plate 78, Figures 3, 3*a*–3*d;* Plate 79, Figures 3, 3*a*, 3*b*, 4*a*, 5; Plate 86 Figures 12–16; Plate 90, Figure 3; Plate 91, Figure 2; Plate 93, Figures 1–3, 5

The type of Stimpson's *Asterias paucispina* represents the immature phase and that of Verrill's *Pisaster papulosus* a mature stage of this form.

The principal distinction lies in the number of dorsolateral spines. In typical examples these stand singly, or in twos and occasionally threes, in one fairly direct to decidedly zigzag longiseries. At the end of the ray a few extra spines are added on either side. These spines or small groups are widely spaced from each other and from the carinals and superomarginals. Certain variants add spines here and there outside the series. Plate 90, Figure 3, represents the primitive form. Similar specimens, having R upward of 120 mm. are not uncommon at Monterey Bay. Plate 93, Figures 1 and 3, is the variation having the spines occasionally in groups of two or three, and with a few scattered ones near the marginals. This intergrades with specimens similar to Plate 93, Figure 4, which is an intergrade with forma *brevispinus*.

In forma *paucispinus* (pl. 79, figs. 3, 3*a*–3*c*) the spines are usually stout with subconical, or acorn-shaped, grooved, differentiated tips. A subforma (pl. 91, fig. 2) with very few, rather inconspicuous dorsolateral and carinal spines but with a multitude of large dentate pedicellariae (often more robust than the spines) is found at Nanaimo, British Columbia, and represents the extreme of difference from the multispinous subforma of *brevispinus*. This small spined variety is represented by a giant specimen from station 4219, vicinity of Port Townsend, having R 315 mm. It also has very numerous "major" pedicellariae which are not so robust as the spines. A specimen (pl. 93, fig. 2) from soft green mud, Monterey Bay, also has very few, rather weak spines, but only the usual equipment of pedicellariae. A variation with spines similar to this, but with almost no larger straight pedicellariae occurs at Bradley Lagoon, British Columbia. In forma *brevispinus* nearly as wide a variation in the number of straight pedicellariae is found.

Papulae are normally very numerous and, on account of the fewer spines, are rather more conspicuous than in *brevispinus*. They occur in clusters interspersed with groups of crossed and furcate pedicellariae, with which, in alcoholic specimens, it is easy to confuse them. As in other species of *Pisaster* the ventral papulae are long, and increase in number with size of animal. In large specimens they form dense masses between the ventral spines. Verrill's *Pisaster papulosus*, characterized by few spines and very numerous papulae, is the normal adult of *paucispinus* of the extreme type.

Superomarginal spines one, or sporadically two, to a plate, sometimes smaller sometimes larger than the dorsolaterals. In the curious subforma from Nanaimo (pl. 91, fig. 2) several consecutive superomarginal (and carinal) plates may lack spines. The available lime seems to have gone into pedicellariae. There are indications that in some cases the spines have been absorbed.

Inferomarginal spines two (sporadically three). Actinal spines in two, rarely three, longiseries. The inner spine, when present, is generally slenderer than the others. The big specimen from station 4219 has sometimes two, sometimes three spines in the cross series of the actinal system, or four and five counting the inferomarginals. Forma *brevispinus* has usually three or four, exceptionally five longiseries of actinals at base of ray. There is no constant characteristic difference distinguishing the spines in the two formae.

The adambulacral and oral armature is similar to that of forma *brevispinus*.

The pedicellariae of forma *paucispinus* are like those of *brevispinus* and vary in number within about the same limits. Specimens from Nanaimo have an extraordinary equipment of large dentate pedicellariae. The bouquets of adambulacral straight pedicellariae are often very voluminous and can be extended in life to the ends of the papulae which are adjacent to the adambulacral plates. They apparently afford some protection to these papulae and to the tube feet, among which the long peduncles of the bouquets twine. (Pl. 74, figs. 4, 4*a*, 4*b*, 4*e*; pl. 78, fig. 3, 3*a*–3*c*; pl. 79, fig. 5 (inferomarginal).)

Madreporic body large, exposed, situated as in *brevispinus*.

Color in life: Rose pink with sage green papular areas. There is apparently no constant difference in color from f. *brevispinus*. A specimen from station 4503: Abactinal spines light rose purple; general surface olive buff; papular areas dark grayish green; actinal surface, light rose purple.

Young.—Plate 86, Figures 12–16. These figures are intended to facilitate comparison between the young of the three species of Pisaster.

The young, by reason of the paucity of dorsolateral spines, are all referable to forma *paucispinus*. Forma *brevispinus* passes through this stage and adds spines, while the adults of *paucispinus* maintain the juvenile arrangement of one dorsolateral series. Figure 12 has R 15 mm. and one actinal series of spines for half the length of ray. The furcate and crossed pedicellariae are spaced, in circles, around the spines and form groups of two or three in between. Figure 13 has R 30 mm. The actinals extend nearly to tip of ray. Both have relatively few dentate straight pedicellariae.

One means of distinguishing the young of the three species, especially *brevispinus* from *ochraceus*, is the furcate pedicellariae, the jaws of which are characteristic.

Skeleton.—There are no striking points of difference between the skeletons of *brevispinus* and *ochraceus*. In *brevispinus* the prominent groups of dorsolateral spines are seated upon plates much larger and more convex than the others. The same development is seen in *ochraceus* forma *nodiferus*. In both species the skeleton is strengthened, during the growth of the species, by the addition of internal ossicles. This is especially observable in a series of transverse superactinal partitions or buttresses which pass from the ambulacral across to the superomarginal systems. Between these partitions are deep recesses or wells into which the highly important actinal papulae open.

The mouth plates appear to be more deeply sunken in this species than in the other two, but as considerable movement is possible, variation is apparent. When the actinostome is near the upper surface of the disk, as it frequently is, the adoral carina is at right angles to the substratum upon which the animal is crawling. There are fewer longiseries of actinal plates (which are a little larger) than in *ochraceus*.

In young specimens (pl. 79, fig. 4*a*) the skeleton has a series of wide intervals or spaces adjacent to the superomarginals and the primary dorsolaterals are relatively big. As in *ochraceus* the carinals lose their 4-lobed contour later in life.

Very young specimens (R 14 mm.) have, on the superomarginal plates, a very small area of hyaline bosses. These disappear in specimens with R 18 mm. In young of *P. giganteus capitatus* the superomarginals have relatively more surface, are more triangular in shape, and these specialized areas cover nearly the whole surface. They are well-marked in the young of *ochraceus*, having R 22 mm.

Type of Pisaster brevispinus.—Cat. No. 1285 U.S.N.M.

Type locality.—Near mouth of San Francisco Bay, Calif., 10 fathoms, sand.

Distribution.—Sitka, Alaska (Verrill) to Santa Barbara, Calif.; lowest tide to 56 fathoms, sand, or mud and sand.

Forma *brevispinus* has been taken in the Puget Sound region, Washington, and from Crescent City to Monterey Bay, Calif.

Forma *paucispinus* (type locality, Puget Sound) ranges from Sitka to Santa Barbara.

Specimens examined.—One hundred and fifteen, in addition to many from Monterey Bay.

Specimens of Pisaster brevispinus examined

Station	Locality	Depth	Nature of bottom	*f. brevispinus*	*f. paucispinus*	Remarks
		Fathoms				
3110	Vicinity Half Moon Bay, Calif	39	Rocky	1		
3111	do	20	Gray sand		2	4 intermediate.
3122	Between Point Año Nuevo and Santa Cruz, Calif.	38	Gray sand, mud		2	
3147	do	56	Brown mud		1	
3153	Vicinity Point Reyes, Calif	32	Green mud		1	
3154	do	20	Black sand, mud		3	
4219	Vicinity Port Townsend, Wash	16	Green mud, sand		1	
4487	3.7 miles southeast Santa Cruz Point, Calif. (Monterey Bay).	18	Hard gray sand	1		
4492	Monterey Bay, 7 miles southeast Santa Cruz.	26	Soft green mud		1	
4501	Monterey Bay	12	Hard coarse sand	7	6	2 intermediate.
4503	Monterey Bay (off Soquel)	7	Gray sand	4	25	
4519	Monterey Bay (off Moss Landing)	35	Hard gray sand			1 intermediate.
4560	Monterey Bay (off Soquel Point)	10	Fine gray sand	1	3	
4561	do	15	Coarse sand, shells		4	
4562	Monterey Bay (8 miles southeast Santa Cruz).	10	Hard sand, rocks		6	
4563	Monterey Bay (off Soquel Point)	8	Rocky		3	
5718	San Francisco Bay (middle)	7½	Gray mud		1	
5762	San Francisco Bay (lower)	6	Mud		1	
	Kasaan Bay, Prince of Wales Island, southeast Alaska.				2	T. H. Streets.
	Bradley Lagoon, British Columbia				1	W. F. Thompson.
	Barclay Sound, Vancouver Island, British Columbia.				2	
	Nanaimo, Vancouver Island, British Columbia.	Wharves			3	
	Departure Bay, British Columbia	[1] 10	Soft sand		2	
	Lopez Island, San Juan Island, Wash	15–25		2		Miss M. Bush.

[1] Feet.

Specimens of Pisaster brevispinus examined—Continued

Station	Locality	Depth	Nature of bottom	f. *brevispinus*	f. *paucispinus*	Remarks
		Fathoms				
	Gulf of Georgia	--------	--------	1	1	Mus. Comp. Zoöl.
	Puget Sound	--------	--------	--------	4	Do.
	Crescent City, Calif.	--------	--------	2	1	J. O. Snyder.
	Humboldt Bay, Calif.	--------	--------	--------	1	C. M. Drake.
	Tomales Bay, Calif.	--------	Mud flats	--------	2	Intermediate.
	Bolinas, Calif.	--------	--------	1	--------	
	San Francisco Bay (mouth)	Bar.	Sand	1	1	F. W. Weymouth.
	San Francisco Bay, Key Route Pier	--------	--------	1	--------	W. F. Hamilton.
	San Francisco Bay	--------	--------	--------	2	Dr. J. Hornung.
	Half Moon Bay, Calif.	--------	--------	1	--------	Intermediate.
	Monterey Bay, Calif.	Shallow.	Sand	(2)	(2)	Hopkins Marine Station; Mus. Comp. Zoöl. No. 1821.
	San Simeon Bay, Calif.	--------	--------	--------	1	
	Santa Barbara	--------	--------	--------	2	Mus. Comp. Zoöl.

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[2] Numerous.

Remarks.—Verrill's *Pisaster papulosus* is the fully grown phase of the immature specimens to which Stimpson gave the name *Asterias paucispina.* These are figured by Verrill (1914, pl. 36). Figure 1 (Cat. No. 1287, U.S.N.M.) is the cotype, not type; Figure 2 (No. 1286) is the type. Both are somewhat museum worn, but I have numerous specimens, almost identical, as well as smaller and larger ones. Apparently forma *brevispinus* always begins as *paucispinus* and adds spines to the few well-spaced ones of the single dorsolateral series. I have seen only one specimen of *brevispinus* as small as R 53 mm.; most of them have R 100 mm. or more.

Verrill was in doubt concerning the generic position of *paucispinus* because only one series of actinal spines is present in the type. This is only a juvenile condition.

In connection with Verrill's account of *brevispinus* (p. 81) the record of Santa Cruz Island, Calif., is an error. The specimen (1821, M. C. Z.) came from Monterey Bay, off Santa Cruz. The figures representing the crossed pedicellariae of *papulosus* (Verrill, 1914, pl. 76, fig. 2*b*) are wholly inaccurate, being unlike any crossed pedicellariae in *Pisaster*.

CHECK LIST OF ASTEROIDEA OF NORTH PACIFIC AND ADJACENT WATERS

The following check list contains the names and ranges of all species, subspecies, and formae found within the geographical limits covered by the present treatise. After each name is given a reference to part 1 or part 2 of this work, where the species is treated in detail. In order to avoid repetition, the species treated in this concluding installment—namely, the Asteriinae—have not been listed since the names may be found by reference to foregoing pages. Appropriate citations are given for the few species not treated in parts 1 and 2. References to Verrill's Shallow-water Starfishes have been inserted wherever his views or treatment have materially differed from my own. In the Phanerozonia there are few such citations. In the Forcipulata the very wide differences in treatment are not apparent in this check list. But the history of each species is covered by the synonymy which may be found on the page cited. In order to lessen the confusion which exists in the Coscinasteriinae and Asteriinae a list of Verrill's names has been appended to this check list. In a parallel column is given my interpretation of the particular species or variety. Further notes will usually be found in the account of that species or of its formae.

Order PHANEROZONIA Sladen

Suborder PAXILLOSA Perrier

Family PORCELLANASTERIDAE Sladen

EREMICASTER TENEBRARIUS (Fisher), pt. 1, p. 24.

Southern Alaska to the Galapagos Islands; 1,569 to 2,259 fathoms; ooze and soft mud.

EREMICASTER PACIFICUS (Ludwig), pt. 1, p. 29.

Bering Sea to Gulf of Panama and vicinity of Galapagos Islands; 859 to 1,879 fathoms; ooze, soft mud, fine sand.

Family GONIOPECTINIDAE Verrill

CTENODISCUS CRISPATUS (Retzuis), pt. 1, p. 31.

Bering Sea to Sea of Japan and south along the American coast to Gulf of Panama; Arctic Ocean; North Atlantic.

Family ASTROPECTINIDAE Gray

LEPTYCHASTER ARCTICUS (Sars), pt. 1, p. 43.

Circumpolar; North Atlantic; Bering Sea, south to Japan.

LEPTYCHASTER PACIFICUS Fisher, pt. 1, p. 45.

Leptychaster millespina Verrill, 1909, p. 553.

Leptychaster pacificus Fisher, Verrill, 1914, p. 326.

Southern part of Bering Sea to Vancouver Island; 56 to 238 fathoms; sand, pebbles, soft mud.

LEPTYCHASTER ANOMALUS Fisher, pt. 1, p. 48.

Glyphaster anomalus Verrill, 1914, p. 328.

Bering Sea (vicinity Pribilof Islands and west of St. Paul) to southeast Alaska; on the Asiatic side to the Sea of Japan; 32 to 688 fathoms; fine gray or black sand, green mud or pebbles.

LEPTYCHASTER INERMIS (Ludwig).

Parastropecten inermis Ludwig, 1905, p. 76; pl. 4, figs. 21, 22; pl. 21, fig. 177; pl. 22, fig. 126.

Leptychaster inermis Fisher, 1911, p. 53; Clark, 1913, p. 188 (Monterey Bay to Ballenas Bay).

Monterey Bay to Galapagos—Panama region; 659 to 871 fathoms; gray sand, green mud. The small specimen of *anomalus* recorded by me, 1911, p. 52, from 795 to 871 fathoms, Monterey Bay, was probably *inermis*.[28]

LEPTYCHASTER PROPINQUUS Fisher, pt. 1, p. 54.

Vicinity of Commander Islands, Bering Sea; 54 to 72 fathoms; green sand.

TROPHODISCUS ALMUS Fisher.

Bull. U. S. Nat. Mus., vol. 52, 1917, p. 368, pls. 28–30.

Southeast coast of Kamchatka, 51° 16′ N., 157° 48′ W.; 96 fathoms, black sand; northern part of Okhotsk Sea (Djakonov).

TROPHODISCUS UBER Djakonov.

Ann. Musée Zool. Acad. Sci. U. R. S. S., vol. 27, 1926, p. 310, pl. 21, figs. 1, 2.

Southern part of Okhotsk Sea; 30 to 60 fathoms; sand and mud.

DIPSACASTER EXIMIUS Fisher, pt. 1, p. 86.

From north of Monterey Bay to vicinity of San Diego, Calif.; 206 to 525 fathoms; green, black, or yellow mud.

DIPSACASTER BOREALIS Fisher, pt. 1, p. 91.

Bering Sea and south of the Aleutian Islands; 121 to 351 fathoms; sand, green mud.

DIPSACASTER LAETMOPHILUS Fisher, pt. 1, p. 95.

South of Alaska Peninsula (55° 26′ N., 155° 26′ W.); 695 fathoms; mud.

DIPSACASTER ANOPLUS Fisher, pt. 1, p. 97.

Washington to vicinity of San Diego, Calif.; 300 to 800 fathoms; mud, fine sand.

PSILASTER PECTINATUS (Fisher), pt. 1, p. 72.

Bering Sea to Bay of Panama; 1,033 to 1,625 fathoms; green ooze, green mud sand, and hard bottom.

BLAKIASTER RITTERI (Verrill).

Bunodaster ritteri Verrill, Amer. Nat., 1909, p. 554; 1914, p. 322, pl. 84, figs. 1, 1*a*; pl. 104, figs. 1, 2; pl. 105, figs. 1, 1*a*; text figs. 15, 16. As *Blakiaster*, see pt. 1, p. 40 footnote; also Fisher, Bull. Mus. Comp. Zoöl., vol. 54, no. 4, 1911, p. 164.

Although the type is said to be from off San Francisco, it is more likely to have been taken off San Pedro, Calif. I have seen the type which is very closely related to *Blakiaster conicus* Perrier.

ASTROPECTEN ARMATUS Gray, pt. 1, p. 56.

Astropecten siderealis Verrill, 1914, p. 317, pl. 50, fig. 6.

Astropecten braziliensis armatus Döderlein, Die Gattung Astropecten, etc., 1917, p. 84.

Astropecten erinaceus Clark, 1913, p. 188.

Ecuador to San Pedro, Calif.; shore to 30 fathoms; sand, dark brown mud.

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[28] I have examined a specimen of *inermis* dredged in 625 fathoms off Panama (R 12 mm., r 6 mm.). In general form it resembles *L. propinquus*, but has broader superomarginal plates. *Inermis* has six or seven furrow spinelets, *anomalus*, three or four. For a discussion of the generic position of *inermis*, see Fisher, 1911, p. 53. The practical difficulty of recognizing *Parastropecten* for the short-rayed species of *Leptychaster* is there pointed out. Nevertheless Verrill later attempted to maintain two genera (1914, p. 328), although for *Parastropecten* he used *Glyphaster* Verrill, 1909. The generic diagnosis does not cover the known variations of *L. anomalus* nor does it apply to the closely related *L. propinquus*.

I have maintained the species in a broader sense than Döderlein who recognizes *erinaceus* (including *örstedii* Lütken) as a distinct subspecies of *braziliensis*, an Atlantic species. The type of *armatus* came from Ecuador, which is also the type locality of *erinaceus* (the range of which is given as from Ecuador to Lower California). *A. erinaceus* appears to be a forma of *armatus* rather than a distinct subspecies. In any event the name *armatus* can not be restricted to southern California specimens, if these are really distinct from the race called *erinaceus*, since the type of *armatus* is from Ecuador. Nor does it seem wise to make *armatus* a subspecies of a tropical Atlantic form, which is widely separated geographically with a broad land barrier intervening.

Verrill reports (1914, p. 319) a specimen from the cold water off San Francisco, which is obviously an error and leads me to think that his *Blakiaster ritteri* and *Astrometis californica* are also from the warm area of southern California.

This species is far too variable to split into races on the strength of trivial characters.

ASTROPECTEN ORNATISSIMUS Fisher, pt. 1, p. 67.

Vicinity of Guadelupe and Cerros Islands, Lower California, north to Santa Catalina Island and San Pedro, in southern California; 47 to 207 fathoms; fine or coarse sand, green mud.

ASTROPECTEN VERRILLI CALIFORNICUS Fisher, pt. 1, p. 61.

Astropecten californicus Fisher, 1906*c*, p. 299; 1911, p. 61.—Verrill, 1914, p. 319.

Astropecten verrilli de Loriol, Döderlein, 1917, p. 85.

From north of Point Reyes, Calif., to northern Lower California; 10 to 244 fathoms, usually on fine sand, but occurring also on coarse sand, and on mud.

Astropecten verrilli seems, biologically, to be a warm-water offshoot of *californicus*, which in a typical form inhabits cold water (47° to 52° F.). *A. verrilli* has a single longiseries of small tubercles along the superomarginal series. Döderlein classifies it in his *braziliensis* group.

THRISSACANTHIAS PENICILLATUS (Fisher), pt. 1, p. 79.

Washington to Los Coronados Islands, Lower California; 277 to 822 fathoms; green mud or fine sand.

DYTASTER GILBERTI Fisher, pt. 1, p. 101.

Off San Diego, Calif., 2,196 to 2,228 fathoms, gray mud; undoubtedly intergrading with *D. gilberti demonstrans* Ludwig of the Panama region.

Family LUIDIIDAE Verrill

LUIDIA FOLIOLATA Grube, pt. 1, p. 106.

Southeast Alaska to San Diego, Calif., and probably to Mazatlan, Mexico; 10 to 189 fathoms, usually in less than 80 fathoms, and on fine sand or mud; sometimes on hard sand.

LUIDIA LUDWIGI Fisher, pt. 1, p. 113.

Monterey Bay, south to San Pedro, Calif., in 15 to 50 fathoms; mud, sand; gray sand, shells.

LUIDIA ASTHENOSOMA Fisher, pt. 1, p. 116.

From north of Monterey Bay, Calif., to Los Coronados Islands, Lower California; 11 to 339 fathoms; mud, fine sand, broken shells.

Suborder NOTOMYOTA Ludwig, 1910

Myonota Verrill, 1914, p. 310.

Family BENTHOPECTINIDAE Verrill

PECTINASTER AGASSIZI EVOPLUS (Fisher), pt. 1, p. 123.

Pectinaster agassizi Clark, part, 1913, p. 191.

Off southern California, 984 to 1,059 fathoms, gray and green mud.

LUIDIASTER DAWSONI (Verrill), pt. 1, p. 128.

Bering Sea south along the coast of Alaska to Queen Charlotte Islands; 56 to 159 fathoms; pebbles, sand.

NEARCHASTER ACICULOSUS (Fisher), pt. 1, p. 133.

From south of the Alaska Peninsula to Cedros Island, Lower California, in about 300 to 800 fathoms, usually in about 500 to 700 fathoms; principally on green mud.

NEARCHASTER VARIABILIS (Fisher), pt. 1, p. 137.

Southern Bering Sea to southeastern Alaska; 108 to 351 fathoms; gray sand, mud; in shallower water than *aciculosus*.

NEARCHASTER PEDICELLARIS (Fisher), pt. 1, p. 138.

South of Unimak Island, Alaska, 280 fathoms, green mud, rocks.

MYONOTUS INTERMEDIUS (Fisher), pt. 1, p. 141.

Monterey Bay, Calif., 958 to 755 fathoms, very soft mud.

BENTHOPECTEN ACANTHONOTUS Fisher, pt. 1, p. 144.

Southern California, 984 to 1,059 fathoms, mud.

BENTHOPECTEN MUTABILIS Fisher, pt. 1, p. 147.

Off Prince of Wales Island, British Columbia, 1,569 fathoms, gray ooze.

BENTHOPECTEN CLAVIGER Fisher, pt. 1, p. 150.

Southern Bering Sea to Oregon; 987 to 1,064 fathoms; green mud or ooze.

Suborder VALVATA Perrier

Family ODONTASTERIDAE Verrill

PERIDONTASTER CRASSUS (Fisher), pt. 1, p. 154.

Odontaster crassus Fisher, 1911, p. 154.

Peridontaster crassus Koehler, Australasian Ant. Exp. 1911–1914, vol. 8, pt. 1, 1920, p. 195.

Monterey Bay to San Diego, Calif.; 92 to 243 fathoms; gray sand, mud, shells.

Family RADIASTERIDAE Fisher[29]

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[29] For a discussion of this family see Fisher, Starfishes of the Philippine Seas, etc., 1919, p. 215.

Subfamily PRIAMASTERINAE Fisher

GEPHYREASTER SWIFTI (Fisher), pt. 1, p. 175.

From the end of the Aleutian Chain to Washington; 34 to 188 fathoms; rocks.

Family GONIASTERIDAE Forbes

Subfamily PSEUDARCHASTERINAE Sladen

PSEUDARCHASTER PARELII (Düben and Koren), pt. 1, p. 180.

Bering Sea to Kodiak Island and Sea of Japan; 70 to 351 fathoms; sand, mud, gravel. Also North Atlantic.

PSEUDARCHASTER PARELII ALASCENSIS Fisher, pt. 1, p. 185.

Oregon to southern Alaska, 68 to 1,064 fathoms; rocks, sand, mud.

PSEUDARCHASTER PUSILLUS Fisher, pt. 1, p. 187.

North of Monterey Bay, Calif., to San Cristobal Bay, Lower California; 54 to 382 fathoms; mud, sand, sand and pebbles.

PSEUDARCHASTER DISSONUS Fisher, pt. 1, p. 192.

Bering Sea to Oregon; 784 to 1,064 fathoms; green mud.

Subfamily GONIASTERINAE Verrill

MEDIASTER AEQUALIS Stimpson, pt. 1, p. 198.

Alaska Peninsula (Chignik Bay) south to northern Lower California; 9 to 160 fathoms; rocks and shells, hard sand, gravel, clay, pebbles, green mud.

MEDIASTER TENELLUS Fisher, pt. 1, p. 202.

Southern California, 291 to 510 fathoms; mud, rocks.

M. transfuga Ludwig is probably a form of this species.

CERAMASTER PATAGONICUS (Sladen), pt. 1, p. 214.

Ceramaster granularis (Retzius), Verrill, 1914; p. 290.

Southern Alaska to the southern part of Bering Sea; 41 to 134 fathoms; sand, gravel. Also vicinity of Cape Horn; a specimen from Carmen Island, Gulf of California; one from off Cape San Lucas, 491 fathoms (Clark, 1913, p. 193).

Verrill's citation of *granularis* is based on the record of Whiteaves, Straits of Georgia, 40 fathoms. Whatever west coast material he may have seen was too imperfect to figure and hence not suitable for critical study. A record by Ives from Marmot Island, Alaska, is equally open to question, since the same author reported *granularis* from Monterey, Calif., where it certainly does not occur (probably *Mediaster aequalis*).

Verrill's figures are all from Atlantic material.

CERAMASTER JAPONICUS (Sladen), pt. 1, p. 206.

Japan to southern Bering Sea, thence south along the American coast to Oregon; 106 to 786 fathoms; green mud, gray sand.

CERAMASTER LEPTOCERAMUS (Fisher), pt. 1, p. 210.

From Point Conception, Calif., to San Cristobal Bay, Lower California; 284 to 594 fathoms; green mud, sand.

CERAMASTER CLARKI Fisher, pt. 1, p. 217.

Southern Bering Sea to southern California; 334 to 600 fathoms; greenish brown sand.

CERAMASTER ARCTICUS (Verrill), pt. 1, p. 219.

Tosiaster arcticus Verrill, 1914, p. 292, pl. 50, figs. 3, 3*a*; pl. 99, figs. 1, 2.

From Bering Island along the Aleutians to Kodiak Island, Alaska; low tide to 102 fathoms.

CLADASTER VALIDUS Fisher, pt. 1, p. 219.

Amukta Pass, Aleutian Islands; 283 fathoms; black sand, rocky.

HIPPASTERIA SPINOSA Verrill, pt. 1, p. 224.

From southern California to Alaska (Kodiak); 27 to 121 fathoms; gray sand, mud, rocks and mud.

HIPPASTERIA SPINOSA KURILENSIS Fisher, pt. 1, p. 226.

Kuril Islands; 229 fathoms; black sand, pebbles.

HIPPASTERIA LEIOPELTA Fisher, pt. 1, p. 227.

Sea of Okhotsk to southern Bering Sea; 48 to 69 fathoms; sand, pebbles.

HIPPASTERIA LEIOPELTA ARMATA Fisher, pt. 1, p. 230.

Kuril Islands, 229 fathoms (with *kurilensis*).

HIPPASTERIA HEATHI Fisher, pt. 1, p. 231.

Clarence Straits, Alaska; 206 to 248 fathoms; coarse sand, rocky.

HIPPASTERIA CALIFORNICA Fisher, pt. 1, p. 233.

Southern California to Washington, 266 to 847 fathoms.

CRYPTOPELTASTER LEPIDONOTUS Fisher, pt. 1, p. 238.

Santa Cruz Island, California, to Tres Marias Islands, Mexico (*Hippasteria pacifica* Ludwig); 266 to 680 fathoms; sand, gravel.

Family LINCKIIDAE Perrier

LINCKIA COLUMBIAE Gray, pt. 1, p. 242.

Southern California and Lower California; Colombia, west coast; Galapagos Islands; shore to 40 fathoms.

Family PORANIIDAE Perrier

DERMASTERIAS IMBRICATA (Grube), pt. 1, p. 249.

Including *Dermasterias imbricata* var. *valvulifera* Verrill, 1914, p. 308, pl. 97, figs. 2, 2*b*.

Sitka, Alaska, to Monterey Bay, Calif.; at and just below low tide, rocks.

Order SPINULOSA Perrier

Family ASTERINIDAE Gray

PATIRIA MINIATA (Brandt), pt. 1, p. 254.

Asterina miniata Fisher, 1911, p. 254.

Patiria miniata Verrill, 1914, p. 264.

Sitka, Alaska, all the way to San Diego, Calif., thence to the Gulf of California, north of La Paz; low water to 165 fathoms; rocks, shells, gravel, hard sand.

Family ECHINASTERIDAE Verrill [30]

PORANIOPSIS INFLATA (Fisher), pt. 1, p. 261.

Oregon to San Diego, Calif.; 26 to 159 fathoms; rocks, sand, green mud.

This species undoubtedly ranges far south of California, and in deep water it gradually changes to *flexilis*.

PORANIOPSIS INFLATA FLEXILIS Fisher, pt. 1, p. 261.

Central and southern California; 334 to 600 fathoms.

This form probably ranges to the Galapagos Islands where it has been described as *P. mira* (*Alexandraster mirus* Ludwig). *P. mira* (Ludwig) preoccupied in *Poraniopsis* by de Loriol's *P. mira* (Fisher, 1911, p. 261).

HENRICIA SANGUINOLENTA (O. F. Müller), pt. 1, p. 271.

Bering Sea south to the vicinity of the Kuril Islands and on the American coast to Washington. Circumpolar and North Atlantic. In the north Pacific region, 30 to 229 fathoms; sand, mud, gravel.

The above includes variety *pectinata* Verrill (*Cribrella pectinata* Verrill), 1914, p. 230, Eastport, Me. Variety *rudis* Verrill, 1914, p. 233, Point Franklin, Arctic Ocean, 13½ fathoms, sand.

There seems to be little use in naming the legion of variants of this species. It is questionable whether *pectinata* of Eastport, Me., is the same as the Bering Sea variation resembling it.

HENRICIA SANGUINOLENTA forma TUMIDA Verrill.

Henricia tumida Verrill, 1909, pp. 554, 555, fig. 5; 1914, p. 234, pl. 12, figs. 1, 2.

Henricia sanguinolenta eschrichtii Fisher, 1911, p. 276, pl. 67, figs. 1–3; pl. 68, figs. 1–2.

Henricia tumida borealis Verrill, 1914, p. 236, pl. 12, figs. 3, 4.

Henricia arctica Verrill, 1914, p. 239, pl. 87, figs. 3–3*c*, text fig. 13.

Arctic Ocean north of Bering Strait south to Kodiak; westward along Alaskan Peninsula and Aleutian Islands to Bering Island and Kamchatka, to Sea of Okhotsk (Brandt), and south to Simushir, Kuril Islands. Low tide to 53 fathoms.

This form is exactly equivalent to *eschrichtii* of part 1. Verrill's name has been adopted since the type is from Unalaska, while that of *eschrichtii* was from Greenland; and since some doubt exists that the two forms are precisely the same. They are however analogous stouter rayed shallow-water phases of the wide ranging *sanguinolenta*.

Verrill applied three names to this forma—*tumida, borealis, arctica*. He attributed some importance to the temporarily arched disk of brooding females. His *H. tumida borealis* applies to specimens with slenderer rays. Both stout and slenderer rayed forms occur in the same tide pool and are in several lots of specimens, as for instance, Nikolski, Bering Island. The narrower rayed variants intergrade with *sanguinolenta*. Rarely, for reasons unknown, the rays are short, broad, and flaccid. (Attu Island, Fisher, 1911, pl. 68, fig. 2.) Verrill attributes this specimen to Cape Lisburne, Arctic Ocean, and refers it to his *H. arctica*, based on a worn specimen. In my opinion *H. arctica* is but a sporadic variant of *tumida* with the plates and spinelets smaller than usual. The Attu Island example shows that the variation may occur far from the Arctic. Verrill distinguishes *arctica* also by the large number of adambulacral spinelets, in "several" transverse rows. But his Figure 3*a*, Plate 87, shows only *two* transverse rows. Although young specimens of *tumida* often have only one transverse series of spinelets, large examples generally have *two*. Two specimens from the same lot as Verrill's type of *arctica* were recorded by me (1911, p. 278, Cape Lisburne, Henry D. Woolfe) and I find no reason to consider them specifically different from the very variable, unstable *tumida*.

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[30] Verrill described *Echinaster robustus* (1914, p. 207), from Sooke, Vancouver Island. I have examined the type; and Dr. H. L. Clark, a photograph of the type furnished by Dr. W. R. Coe. Neither Clark nor I believe that *robustus* came from Vancouver Island nor from a locality within a thousand miles of Vancouver Island. If "*Echinaster robustus*" is not a genuine new species from Mexico, or south, it is likely an extra "fat" *Echinaster sentus* from Florida. Much of Verrill's material was without attached labels and nothing would have been easier than an inadvertent shift. This actually occurred in the case of "*Pisaster lutkenii*" var. *australis*. Equally unlikely are all records of *Echinaster tenuispinus* from California and north.

Verrill also listed typical *tumida* as *sanguinolenta*, namely, the specimen from Bering Island, N. Grebnitsky (Verrill, 1914, p. 229). I have an example of the same lot which is referable to *tumida*.

HENRICIA LEVIUSCULA (Stimpson), pt. 1, p. 280.

Including *Henricia leviuscula* var. *lunula* Verrill, 1914, p. 218, pl. 88, figs. 2–2*c*; var. *inequalis* Verrill, 1914, p. 219, pl. 88, figs 1, 1*a*; var. *spatulifera* Verrill, 1914, p. 224, pl. 5, fig. 1; pl. 14; text fig. 12; other synonyms as given in pt. 1, p. 280.

Aleutian Islands to Monterey Bay, Calif., in a typical form, and thence south to the Santa Barbara Channel and San Diego, Calif., the southern forms not typical. The typical form is found along shore at low tide, or in comparatively shallow water. Low tide to 53 fathoms.

HENRICIA LEVIUSCULA forma DYSCRITA Fisher.

Henricia leviuscula dyscrita Fisher, 1911, p. 289, pl. 74, figs. 1–5.

Henricia leviuscula var. *dyscrita* Verrill, 1914, p. 223, pl. 12, fig. 6.

Middle and southern California, offshore, 21 to 80 fathoms; sand, stones, mud, and rocks.

This may eventually prove to be a good deep water race of *leviuscula*. It is however rather unstable and a more conservative treatment is to consider it a forma of *leviuscula* in some respects intermediate with *spiculifera*.

HENRICIA LEVIUSCULA SPICULIFERA (Clark).

Cribrella spiculifera Clark, Proc. Boston Soc. Nat. Hist., vol. 29, 1901, p. 328, pl. 2; pl. 4, fig. 1.

Henricia leviuscula multispina Fisher, 1911, p. 286, pl. 72, figs. 1–4; pl. 73, figs. 1, 2.

Henricia spiculifera (Clark), Fisher, 1911, p. 295.

Henricia leviuscula spiculifera Verrill, 1914, p. 220.

Henricia leviuscula var. *multispina* Verrill, 1914, p. 222.

From Oregon to Bering Sea, Bering Strait, the Aleutians, and south on the Asiatic side to Simushir, Kuril Islands; low tide to 238 fathoms.

Plate 72, Figures 1 and 2, and Plate 73, Figures 1 and 2, of part 1, give an excellent idea of this relative of *leviuscula*. Verrill unfortunately figured a Bering Island specimen (of which I have duplicates), instead of Clark's types, which he held for many years. These types came from Puget Sound and are evidently not extreme examples of the race, but are probably nearer to *leviuscula* than is the type of *multi-*

spina. The race as a whole reaches its best development along the Aleutian chain, the type locality of *multispina*.

Typical examples are readily distinguished from *leviuscula* by their delicate and more numerous, rather hyaline spinelets, ending in several delicate thorns. Variations with larger or smaller abactinal plates and slender to stout rays occur. I do not think it is possible to distinguish a northern *multispina* from a southern *spiculifera* and have accordingly united the two.

HENRICIA ASPERA Fisher, pt. 1, p. 293.

Bering Sea (Bering Island, Pribilofs, Aleutian Islands) south along the coast to the Santa Barbara Channel, Calif.; 26 to 313 fathoms; mud, sand, pebbles, shells, rocks.

HENRICIA ASPERA forma **ANNECTENS** Fisher.

Henricia leviuscula annectens Fisher, 1911, p. 291, pl. 70, fig. 2*d*; pl. 71, figs. 1, 3.

Henricia leviuscula var. *annectens* Verrill, 1914, p. 224.

Aleutian Islands to Santa Barbara Channel, Calif., 21 to 135 fathoms; rocks, shells, sand, mud.

This form in most respects is intermediate between *aspera* and *leviuscula* but resembles *aspera* more than *leviuscula*. Specimens referable to this forma have been taken also at station 3220, near Unalaska, 34 fathoms; and station 4784, near Attu, Aleutian Islands, 135 fathoms. The range is probably coextensive with that of *aspera*.

HENRICIA ASTHENACTIS Fisher, pt. 1, p. 297.

Vicinity of Santa Barbara Island, Calif.; Shumagin Islands; Bering Sea (Bowers Bank and off Kamshatka); 178 to 682 fathoms; green and gray sand, green mud, black mud.

HENRICIA LONGISPINA Fisher, pt. 1, p. 299.

From vicinity of Vancouver Island to southern Alaska; 41 to 134 fathoms; soft green mud, gravel, sponges.

HENRICIA LONGISPINA ALEUTICA Fisher, pt. 1, p. 300.

Off Attu Island, Aleutian Islands; 135 fathoms; coarse pebbles.

HENRICIA POLYACANTHA Fisher, pt. 1, p. 302.

Cyllaster polyacantha A. H. Clark, Proc. Biol. Soc. Washington, vol. 29, 1916, p. 61.

Off San Diego, Calif.; 359 fathoms; mud, fine gray sand.

HENRICIA CLARKI Fisher, pt. 1, p. 303.

Cyllaster clarki A. H. Clark, Proc. Biol. Soc. Washington, vol. 29, 1916, p. 61.

Santa Cruz Island, Calif., to the Revillagigedo Islands, Mexico; 124 to 822 fathoms; black sand, fine gray sand, green mud, black mud.

Family SOLASTERIDAE Perrier

SOLASTER ENDECA (Linnaeus), pt. 1, p. 307.

Solaster endeca and *Solaster galaxides* Verrill, 1914, pp. 244, 248; *galaxides*, pl. 46, figs. 2, 2*a*; pl. 87, figs. 5–5*c*; pl. 89 fig. 2.

Bering Sea south to Victoria, British Columbia, and San Juan Islands, Wash.; 12 to 238 fathoms; gray sand, gray green mud, coarse sand. In the North Atlantic and Arctic Ocean. (See von Hofsten, 1915, p. 39.)

Verrill's *galaxides* was founded upon three specimens from the vicinity of Victoria, British Columbia, and Puget Sound, Wash. As pointed out by me in 1911 (p. 308) there is no constant difference between *endeca* and *galaxides*, the distinctions listed by Verrill being rather of the nature of minor individual variations and not constant.

It is probable that the type is now the only one of Verrill's three specimens which is extant.

SOLASTER STIMPSONI Verrill, pt. 1, p. 307.

Solaster stimpsoni Verrill, 1914, p. 254, pl. 10, figs. 1, 2; pl. 11, figs. 1, 2; pl. 15, figs. 1, 2; pl. 46, figs. 1, 1*c;* pl. 94, fig. 2; pl. 95.

Solaster constellatus Verrill, 1914, p. 257, pl. 46, figs. 3, 4; pl. 90, fig. 2; pl. 93; pl. 94, fig. 1.

Southern Bering Sea (Commander Islands), and Kodiak, south to Oregon, in shallow water; low tide to 33 fathoms; rocks and shells.

Since the publication of part 1, I have observed abundant living material at Departure Bay (Canadian Biological Station). I have also examined the type of *constellatus* kindly forwarded by the Provincial Museum, Victoria. In spite of Verrill's vigorous defense (1914, p. 258) of *constellatus*, the fact remains that the alleged species was based upon a single specimen from Puget Sound, from which general region I have handled probably ten times the amount of material available to Verrill. The type does not differ sufficiently from the variable *stimpsoni* (many of which have nine rays) to constitute even a good forma. The larger pseudopaxillae upon which Verrill lays stress are apparent only, due to their having dried with the spinelets fully spread apart. They are well within the normal variation of *stimpsoni*. It is simply a question of adequate material.

SOLASTER DAWSONI Verrill, pt. 1, p. 313.

Monterey Bay to the Aleutian Islands, thence to the Kuril Islands; low tide to 229 fathoms; rocks (Monterey), sand, shells, black sand, green mud.

SOLASTER DAWSONI ARCTICA Verrill.

Verrill, 1914, p. 253, pl. 87, figs. 6, 6*a;* text fig. 14.

Solaster dawsoni part, Fisher, 1911, p. 315 (Point Franklin); pl. 85, fig. 1 (topotype).

Point Franklin, 10 miles west, 13½ fathoms, sand.

Verrill's type is one of the specimens collected by the Point Barrow expedition (John Murdoch) and is of the same lot as the two recorded by me. It seems probable that this is an arctic race of *dawsoni*.

SOLASTER PAXILLATUS Sladen, pt. 1, p. 315.

From south of Yokohama, Japan, to Bering Sea, thence to vicinity of Kodiak Island, Alaska; 56 to 350 fathoms; gray sand, pebbles, mud.

It is possible that Clark's record of this species (1913, p. 196) from off Santa Rosa and Santa Cruz Islands, Calif., 534 to 640 fathoms, refers to *S. exiguus*.

SOLASTER EXIGUUS Fisher, pt. 1, p. 319.

Off Anacapa Island, Calif.; 603 fathoms, green mud.

SOLASTER BOREALIS (Fisher), pt. 1, p. 320.

From off San Diego, Calif., to Bering Sea, thence to Honshu, Japan; 225 to 1,044 fathoms; blue, green, brown, gray, black mud.

SOLASTER HYPOTHRISSUS Fisher, pt. 1, p. 324.

Shumagin Islands to Attu, Aleutian Islands; 135 to 625 fathoms; green mud, coarse pebbles.

CROSSASTER PAPPOSUS (Linnaeus), pt. 1, p. 325.

Solaster papposus, Fisher, 1911, p. 325.

Circumpolar, through Bering Strait, into Bering Sea; thence south along the west coast of North America to Washington; on the Asiatic side to the Sea of Okhotsk. North Atlantic. (See von Hofsten, 1915, p. 32.) In the north Pacific region, lowest tide to 283 fathoms; from a variety of bottom including gravel, rocks and shells, sand, mud.

HETEROZONIAS ALTERNATUS (Fisher), pt. 1, p. 331.

Washington to San Diego; 316 to 603 fathoms; green and black mud, fine sand.

LOPHASTER FURCILLIGER Fisher, pt. 1, p. 334.

From south of the Alaska Peninsula to southern California, thence to the Galapagos Islands; 192 to 1,100 fathoms; green mud, sand, globigerina; also rocks, shells, fine gray sand.

LOPHASTER FURCIFER VEXATOR Fisher, pt. 1, p. 338.

Lophaster furcilliger vexator Fisher, 1911, p. 338.

Southern Bering Sea to northern California; 75 to 350 fathoms, typically in less than 200; black sand, mud, gravel.

Family KORETHRASTERIDAE Danielssen and Koren

PERIBOLASTER BISERIALIS Fisher, pt. 1, p. 341.

Southern Bering Sea and off southern California; 57 to 440 fathoms; green and gray mud, fine gray sand, pebbles, rocky.

Family PTERASTERIDAE Perrier

PTERASTER MILITARIS (O. F. Müller) pt. 1, p. 346.

Pteraster militaris Verrill, 1914, p. 272.

Pterasterides aporus (Ludwig) Verrill, 1914, p. 277.

Bering Sea to Washington; 41 to 344 fathoms; green mud, gray sand, gravel. Arctic; North Atlantic. (See von Hofsten, 1915, p. 47.)

PTERASTER TRIGONODON Fisher, pt. 1, p. 348.

Off Santa Cruz Island, Calif.; 447 to 510 fathoms; black mud, rocks.

PTERASTER JORDANI Fisher, pt. 1, p. 350.

From northern Lower California to Washington; 266 to 984 fathoms; mud or sand.

PTERASTER MARSIPPUS Fisher, pt. 1, p. 352.

Bering Sea, 52 to 351 fathoms; gravel, sand.

PTERASTER COSCINOPEPLUS Fisher, pt. 1, p. 354.

Off southern and central California; 281 to 1,062 fathoms; mud, sand.

PTERASTER TEMNOCHITON Fisher, pt. 1, p. 355.

Aleutian Islands, Attu to Unalaska; 56 to 135 fathoms; pebbles.

PTERASTER PULVILLUS Sars, pt. 1, p. 355.

Near Bering Island, Bering Sea; 72 fathoms; pebbles. Also Arctic Ocean and North Atlantic (off Maine to Newfoundland); Norwegian coast, from 60° to Finmark; Barents Sea; Kara Sea.

PTERASTER TESSELATUS Ives, pt. 1, p. 359.

Pteraster tesselatus Ives, Proc. Acad. Nat. Sci. Phila., 1888, p. 421.—Fisher, 1911, p. 359, pl. 104, figs. 1–5.—Verrill, 1914, p. 268, pl. 32, figs. 1, 2; pl. 86, figs. 4–4*c*; pl. 97, fig. 1.

Pteraster multispinus Clark, Proc. Boston Soc. Nat. Hist., vol. 29, no. 15, 1901, p. 328, pl. 3, figs. 1, 2.—Fisher, 1911, p. 359.—Verrill, 1914, p. 271.

? Pteraster gracilis Clark, Proc. Boston Soc. Nat. Hist., vol. 29, 1901, p. 326, pl. 3, figs. 3, 4.—Fisher, 1911, p. 349.—Verrill, 1914, p. 271.

Pteraster tesselatus hebes Verrill, Amer. Journ. Sci., vol. 28, 1909, p. 61; 1914, p. 270, pl. 96, figs. 1, 2.

Bering Sea (Bering Island, Aleutian Islands, Pribilofs, Hagemeister Island) south to Strait of Fuca and Strait of Georgia; gravel, sand, mud.

Verrill has given some notes on the types of *Pteraster multispinus* and *gracilis*, both young specimens; neither, in my opinion, are valid species. It is possible that *gracilis* is the young of *militaris*. Verrill's *hebes* is a dried and distorted *tesselatus* from Departure Bay, British Columbia, where typical *tesselatus* has been collected.

PTERASTER TESSELATUS ARCUATUS Fisher, pt. 1, p. 363.

Monterey Bay, 56 to 46 fathoms, rocks.

PTERASTER OBSCURUS (Perrier), pt. 1, p. 363.

Pteraster obscurus (Perrier), Fisher, 1911, p. 363 (synonymy as given).—Verrill, 1914, p. 274.

Pteraster obscurus var. *octaster* Verrill, 1914, p. 276.

Bering Sea, from Bering Straits south to Bering Island, Kamchatka, and Unalaska; 17 to 85 fathoms; mud, black sand, fine gray sand. Also 50 to 145 fathoms in the North Atlantic, whence it ranges into the Arctic (Spitzbergen, Greenland). Evidently circumpolar. (See von Hofsten, 1915, p. 50.)

DIPLOPTERASTER MULTIPES (Sars), pt. 1, pl. 371.

In the north Pacific from San Diego, Calif., and Suruga Gulf, Japan, north to southern part of Bering Sea; 81 to 640 fathoms; mud, sand, gravel. Also in the North Atlantic, on the west side from 35° to 45° north latitude, and on the east side from Norway and Barents Sea; 50 to about 580 fathoms.

HYMENASTER KOEHLERI Fisher, pt. 1, p. 373.

Southern Bering Sea (between Unimak Island and the Pribilofs); 1,771 fathoms; blue ooze.

HYMENASTER PERISSONOTUS Fisher, pt. 1, p. 376.

From off Rosario Bay, Lower California, to Bering Sea; 225 to 1,771 fathoms; gray mud, blue and green ooze.

HYMENASTER QUADRISPINOSUS Fisher, pt. 1, p. 380.

Bering Sea to Rosario Bay, Lower California, and probably south to the vicinity of Panama; 1,059 to 1,771 fathoms; green mud, gray and blue ooze.

Order FORCIPULATA Perrier

Suborder BRISINGINA Fisher

Family BRISINGIDAE Sars

CRATEROBRISINGA SYNAPTOMA Fisher, pt. 2, p. 10.

Off British Columbia (52° 39′ 30″ N., 132° 38′ W.); 1,588 fathoms; gray ooze, coarse stones.

BRISINGELLA EXILIS (Fisher), pt. 2, p. 13.

Off southern California from San Diego to Santa Barbara Island; 448 to 1,059 fathoms; green mud.

BRISINGELLA PUSILLA Fisher, pt. 2, p. 16.

Off southern California from San Diego to Santa Cruz Island; 301 to 1,059 fathoms; green and black mud.

BRISINGELLA PANNYCHIA Fisher, pt. 2, p. 18.

Bowers Bank, Bering Sea; 771 fathoms; green mud.

FREYELLASTER FECUNDUS (Fisher), pt. 2, p. 21.

Off Point Pinos, Monterey Bay, Calif.; 755 to 1,062 fathoms; soft gray mud, hard sand, and mud.

FREYELLA MICROPLAX (Fisher), pt. 2, p. 25.

British Columbia to central California; 861 to 1,588 fathoms; mud and sand.

FREYELLA INSIGNIS Ludwig, pt. 2, p. 27.

Gulf of Panama to southern California; 1,772 to 2,228 fathoms; on gray mud, green mud, brown mud, and globigerina ooze.

ASTROCLES ACTINODETUS Fisher, pt. 2, p. 29.

Off British Columbia (55° 20′ N., 136° 20′ W.); 1,569 fathoms; gray ooze.

Suborder ASTERIADINA Fisher

Family ZOROASTERIDAE Sladen

ZOROASTER OPHIURUS Fisher, pt. 2, p. 34.

Bering Sea to Lower California (off Ballenas Bay and San Rosario Bay); 879 to 1,217 fathoms; mud and fine black sand.

ZOROASTER ACTINOCLES Fisher, pt. 2, p. 37.

Northwest of Yunaska Island, Aleutian Islands; 1,217 fathoms; fine black sand.

ZOROASTER EVERMANNI Fisher, pt. 2, p. 40.

Off southern California, San Diego to Santa Cruz Island; 216 to 510 fathoms; green mud, black mud, gray sand.

ZOROASTER EVERMANNI MORDAX Fisher, pt. 2, p. 43.

From Washington to southern California; 239 to 760 fathoms; in south only in over 600 fathoms; green mud.

MYXODERMA SACCULATUM Fisher, pt. 2, p. 45.

Bowers Bank, Bering Sea, and off central California, undoubtedly intergrading with the southern form from off southern California; 550 to 766 fathoms; green mud, sand.

MYXODERMA SACCULATUM ECTENES Fisher, pt. 2, p. 49.

Off southern California from the vicinity of Santa Cruz Island to Los Coronados Islands; 510 to 100 fathoms; gray mud, green mud, black mud.

MYXODERMA PLATYACANTHUM (H. L. Clark), pt. 2, p. 52.

From Point Conception, Calif., to San Cristobal Bay, Lower California; 205 to 287 fathoms; green mud.

MYXODERMA PLATYACANTHUM RHOMALEUM Fisher, pt. 2, p. 54.

From off Oregon (43° 46′ N.) to central California; 277 to 296 fathoms; gray sand. Intergrades off San Luis Obispo County with *platyacanthum*.

Family ASTERIIDAE Gray

Subfamily PEDICELLASTERINAE Fisher

PEDICELLASTER MAGISTER Fisher, pt. 2, p. 59.

Southern Bering Sea, from the Commander Islands to Unimak, and north to 57°; south along the Alaskan coast to Kasaan Bay, Prince of Wales Island; 12 to 121 fathoms; gravel, black and gray sand; green mud.

PEDICELLASTER MAGISTER MEGALABIS Fisher, pt. 2, p. 64.

From vicinity of San Diego, Calif., to Washington; 284 to 530 fathoms; green and yellow mud, or black sand and gravel.

ANTELIASTER COSCINACTIS Fisher, pt. 2, p. 70.

Off Santa Cruz Island, Calif.; 447 to 510 fathoms; black mud, rocks.

ANTELIASTER MICROGENYS Fisher, pt. 2, p. 73.

South of Santa Cruz Island, Calif.; 48 fathoms; fine gray sand.

ANTELIASTER MICROGENYS NANNODES Fisher, pt. 2, p. 74.

Bowers Bank, Bering Sea; 247 fathoms; gray sand, green mud.

TARSASTER ALASKANUS Fisher, pt. 2, p. 78.

Off Indian Point, vicinity Naha Bay, Behm Canal, Alaska; 240 to 108 fathoms; rocky.

AMPHERASTER MARIANUS (Ludwig), pt. 2, p. 81.

From Tres Marias Islands, Mexico, to Washington; 277 to 676 fathoms; black, green, yellow mud, gray sand, rocks.

AMPHERASTER CHIROPLUS Fisher, pt. 2, p. 84.

Off Santa Cruz Island, Calif.; 447 to 510 fathoms; black mud, rocks.

AMPHERASTER ATACTUS Fisher, pt. 2, p. 86.

Off Los Coronados Islands, vicinity of San Diego, Calif.; 266 to 323 fathoms; gray sand.

Subfamily LABIDIASTERINAE Verrill

RATHBUNASTER CALIFORNICUS Fisher, pt. 2, p. 89.

Off California, from vicinity of San Diego to Point Arena; 207 to 369 fathoms; mud, gray sand, black sand, mud and shale.

Subfamily COSCINASTERIINAE Fisher

STYLASTERIAS FORRERI (de Loriol), pt. 2, p. 96.

Southern Alaska to San Diego, Calif.; 16 to 291 fathoms; usually on rocky bottom.

DISTOLASTERIAS NIPON (Döderlein), pt. 2, p. 103.

Japan Sea (Peter the Great Bay); Japan; Hong Kong; low tide to 81 fathoms.

SCLERASTERIAS HETEROPAES Fisher, pt. 2, p. 112.

Half Moon Bay to south of San Diego, Calif.; 27 to 85 fathoms; fine sand, rocks, mud.

ASTROMETIS SERTULIFERA (Xantus), pt. 2, p. 119.

Gulf of California to Santa Barbara, Calif.; very low tide to 33 fathoms.

ASTROMETIS CALIFORNICA (Verrill), pt. 2, p. 126.

Said to be from off San Francisco, but more likely from off San Pedro, Calif. Probably only a variant of *sertulifera*.

LETHASTERIAS NANIMENSIS (Verrill), pt. 2, p. 132.

Strait of Fuca and Strait of Georgia; 25 to 40 fathoms; gray sand, pebbles, mud.

LETHASTERIAS NANIMENSIS CHELIFERA (Verrill), pt. 2, p. 134.

Saghalien to Bering Strait, thence to Gulf of Alaska off Kodiak Island (Kamchatka, Commander Islands, Aleutian Islands, Bering Sea, Alaska Peninsula); low tide to 93 fathoms; sand, gravel, sand and mud, clayey mud.

ORTHASTERIAS KOEHLERI (de Loriol), pt. 2, p. 139.

Yakutat Bay, Alaska, to Santa Rosa Island, Calif.; lowest tide and subtidal zone to 125 fathoms; rocks, rocks and sand or mud.

—— forma **KOEHLERI**, pt. 2, p. 145.

Distribution of the species.

—— forma **LEPTOSTYLA** Fisher, pt. 2, p. 145.

Strait of Fuca; Behm Canal, Alaska; 39 to 100 fathoms; green mud, pebbles, rocks.

—— forma **BIORDINATA** Verrill, pt. 2, p. 146.

Vancouver Island; low tide; rocks.

—— forma **MONTEREYENSIS** Fisher, pt. 2, p. 146.

Monterey Bay; subtidal zone; very rocky situations.

Subfamily PYCNOPODIINAE Verrill

LYSASTROSOMA DESMIORA Clark, pt. 2, p. 151.

Gulf of Tartary.

PYCNOPODIA HELIANTHOIDES (Brandt), pt. 2, p. 154.

Unalaska, Aleutian Islands, to San Diego, Calif.; intertidal, in rocky situations, to 238 fathoms; sand.

Lee Boone [31] has recorded from Espiritu Santo Island, Gulf of California, under the name *Heliaster kubiniji* (pl. 4), a specimen of *Pycnopodia helianthoides* which can not be located in the Bingham Oceanographic Collection. In a letter, Mr. A. E. Parr, in charge of the collection, informs me that some of the material of this expedition was inadequately labeled. Locality highly improbable for *Pycnopodia*.

Subfamily ASTERIINAE (Verrill, part)

All species and formae of this subfamily believed to be valid are treated in this volume and may be taken, seriatim, for a check list.

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[31] Echinoderms from the Gulf of California and the Perlas Islands, Bulletin Bingham Oceanographic Collection, vol. 2, art. 6, Dec., 1918, p. 7, pl. 4.

LIST OF SPECIES, SUBSPECIES, AND VARIETIES OF ASTERIIDAE IN VERRILL'S SHALLOW-WATER STARFISHES, 1914, WITH THEIR EQUIVALENT IN THE PRESENT MONOGRAPH [32]

Pisaster ochraceus, 69	*P. ochraceus.*
	P. ochraceus segnis.
—— *ochraceus* var. *nodiferus*, 72	*P. ochraceus* forma *nodiferus.*
—— *confertus*, 73	*P. ochraceus* forma *confertus.*
—— *fissispinus*, 76	*P. ochraceus* forma *ochraceus.*
—— *brevispinus*, 77	*P. brevispinus* forma *brevispinus.*
—— *capitatus*, 81	*P. giganteus capitatus* (part).
	P. giganteus (part).
—— *lütkeni*, 83	Do.
—— *lütkeni* var. *australis*, 88	Do.
—— *giganteus*, 89	Do.
—— *papulosus*, 91	*P. brevispinus* forma *paucispinus.*
—— *grayi*, 97	*Leptasterias polaris katherinae.*
—— *paucispinus*, 98	*P. brevispinus* forma *paucispinus.*
Marthasterias sertulifera, 100	*Astrometis sertulifera* (part).
Asterias victoriana, 102	*Evasterias troschelii* forma *troschelii.*
—— *polythela*, 104	*Leptasterias polaris acervata* forma *polythela.*
—— *nanimensis*, 105	*Lethasterias nanimensis.*
—— *acervata*, 107	*Leptasterias polaris acervata* forma *acervata.*
—— *katherinae*, 112	*Leptasterias polaris katherinae.*
—— *multiclava*, 114	*Leptasterias camtschatica.*
	L. camtschatica dispar forma *nitida.*
Leptasterias inaequalis, 117	*Evasterias troschelii*, young.
—— *leptalea*, 119	*L. leptalea.*
—— *arctica*, 120	*L. arctica.*
—— *coei*, 123	*L. coei* (part).
—— *macouni*, 124	*Evasterias troschelii.*
—— *vancouveri*, 125	*L. hexactis vancouveri.*
—— *hexactis*, 126	*L. hexactis* forma *hexactis.*
	L. pusilla.
—— *aequalis*, 127	*L. aequalis* forma *aequalis.*
—— *aequalis* var. *compacta*, 130	Do.
—— —— var. *concinna*, 132	Do.
—— —— var. *nana*, 132	*L. aequalis* forma *nana.*
—— *epichlora*, 132	*L. hexactis* (part).
	L. alaskensis (part).
—— *epichlora alaskensis*, 136	*L. alaskensis* (part).
—— —— *alaskensis* var. *carinella*, 137	Do.
—— —— *alaskensis* var. *siderea*, 137	*L. hexactis* forma *siderea.*
—— —— *miliaris*, 138 [33]	
—— —— *miliaris* var. *regularis*, 139	*L. hexactis* forma *regularis.*
—— —— *miliaris* var. *subregularis*, 139 [34]	
—— —— *miliaris* var. *subnodulosa*, 139	*Evasterias troschelii*, young.
—— —— *plena*, 140	*L. hexactis* forma *plena.*
—— —— *pugetana*, 142	*L. hexactis* forma *regularis.*

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[32] These are given in the order of their occurrence; the figure following the name is the page upon which the description occurs In the right column is the equivalent form.

[33] This "race" probably includes at least two distinct forms of which the six rayed may be young *L. hexactis* forma *plena* while the five rayed is not improbably young *Evasterias troschelii* forma *alveolata* or *acanthostoma*. No definite type was indicated and no specimen can be found. The measurements indicate a young specimen (R 16 mm., r 5 mm.).

[34] Type lost. This is another young specimen, probably an individual variant of some form of *L. hexactis;* possibly it is a young six-rayed *Evasterias* as two actinal rows of spines are indicated—very unusual for a small *Hexasterias.*

Leptasterias dispar, 142	*L. camtschatica dispar* forma *dispar*.
—— *obtecta*, 144	*L. groenlandica* forma *groenlandica*.
Stenasterias macropora, 145	*S. macropora*.
Stephanasterias albula, 147	*S. albula*.
Ctenasterias cribraria, 148	*Leptasterias groenlandica* forma *cribraria*.
Evasterias troschelii, 151	*E. troschelii*.
—— *troschelii* var. *rudis*, 158	*E. troschelii* forma *troschelii* (part).
—— *troschelii* var. *densa*, 161	*E. troschelii* forma *acanthostoma*, young.
—— *troschelii* var. *alveolata*, 162	*E. troschelii* forma *alveolata* (part).
—— *troschelii* var. *subnodosa*, 163	*E. troschelii* forma *troschelii* (part).
—— *troschelii* var. *parvispina*, 163	*E. troschelii* forma *alveolata*, young.
—— *acanthostoma*, 165	*E. troschelii* forma *acanthostoma*.
Orthasterias columbiana, 168	*O. koehleri*.
—— *biordinata*, 173	*O. koehleri* forma *biordinata*.
—— *californica*, 174	*Astrometis californica*.
—— *koehleri*, 175	*O. koehleri*.
—— *dawsoni*, 175	*Astrometis sertulifera* (part).
—— *merriami*, 177	*Leptasterias coei* (part). *Leptasterias polaris katherinae* (part).
—— *forreri*, 179	*Stylasterias forreri*.
—— *forreri forcipulata*, 180	Do.
—— *leptolena*, 182	Do.
—— *gonolena*, 184	*Astrometis sertulifera* (part).
Distolasterias chelifera, 185	*Lethasterias nanimensis chelifera*.
Parasterias albertensis, 187	*Asterias amurensis*.
Allasterias rathbuni, 189	Do.
—— *rathbuni nortonensis*, 191	Do.
—— *anomala*, 193	*Asterias amurensis* forma *anomala*.
Pycnopodia helianthoides, 198	*P. helianthoides*.

SUMMARY OF THE ASTERIINAE, NOTASTERIINAE, AND NEOMORPHASTERINAE OF THE NORTHERN HEMISPHERE[35]

This summary, like that for the southern hemisphere, is not a revision but a review. It will perhaps prove useful as a background for the foregoing detailed account of the north Pacific fauna. To avoid repetition of matter, all genera and species which have been treated in the main body of this work are followed by the page on which fuller information may be found.

Subfamily ASTERIINAE (Verrill, part)

Genus APHANASTERIAS Fisher, p. 159

1. APHANASTERIAS PYCNOPODIA Fisher, p. 160.

Genus APHELASTERIAS Fisher

Aphelasterias FISHER, Ann. and Mag. Nat. Hist., ser. 9, vol. 12, p. 602. Type, *Asterias japonica* Bell.

Diagnosis.—Diplacanthid Asteriinae resembling 5-rayed *Stephanasterias;* abactinal plates small, numerous, imbricated, with small papular areas, not longiserially arranged but in somewhat irregular transverse series, on either side of a definite carinal series; no actinal plates; abactinal spinelets small (surrounded by circlets of small crossed pedicellariae) isolated or in small groups, the general surface having a neat appearance; superomarginals and inferomarginals regular, larger than abactinals, each bearing a transverse comb of three or four spines (the inferomarginals the larger) which carry groups of crossed pedicellariae; papulae compound; not fissiparous; gonads opening just above superomarginals at a distance from interbrachial angle; straight pedicellariae small, compressed, lanceolate; no adambulacral spine pedicellariae.

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[35] Genera arranged alphabetically; for key, see page 3.

1. APHELASTERIAS JAPONICA (Bell).

Asterias japonica Bell, Proc. Zool. Soc. London, 1881, p. 515, pl. 48, figs. 6, 6*a*–6*b*.—Döderlein, Zool. Anz. vol. 25, 1902, p. 335. (*Asterias japonica* Stimpson is a nomen nudum.)
Asterias torquata Sladen, Challenger Asteroidea, 1889, p. 570, pl. 102, figs. 1–4.

I have examined specimens from the following Japanese localities: Otaru (Hokkaido), Same (Rikuoku), Ayukawa, Tsuruga (Echizen). A single specimen from *Albatross* station 4808, Tsuruga Strait, 47 fathoms, sand, shells, coarse gravel, is referable to Sladen's *torquata* which deserves recognition as a deep water forma of *japonica*. (See pl. 72, fig. 4.)

—— forma TORQUATA Sladen.

Asterias torquata Sladen, 1889, p. 570, pl. 102, figs. 1–4.

Off Yokohama; Tsuruga Strait, 5 to 47 fathoms.

Genus ASTERIAS Linnaeus, p. 5

1. ASTERIAS AMURENSIS Lütken, p. 6.
2. ASTERIAS AMURENSIS ROLLESTONI Bell.

Asterias rollestoni Bell, Proc. Zool. Soc. 1881.—Döderlein, 1902, p. 33.
Asterias amurensis Sladen 1889, p. 575.
Allasterias forficulosa Verrill, 1914, p. 194, pl. 83, figs. 3–3*c*; pl. 84, fig. 1; text figs. 10, 11.

Warmer waters of Japan.

3. ASTERIAS AMURENSIS MIGRATA (Sladen).

Asteracanthion rubens (Linnaeus) var *migratum* Sladen, Journ. Linn. Soc. vol. 14, 1879, p. 432,
Allasterias migrata Verrill, 1914, p. 373.

Korean Strait. The two types which I have examined are very immature, R being 16 mm. in the larger. They are possibly the young of *versicolor*. The skin is mottled dark and light brown, as in that species.

4. ASTERIAS FORBESI (Desor).

Asteracanthion forbesi Desor, Proc. Boston Soc. Nat. Hist. vol. 3, 1848, p. 67.
Asterias arenicola Stimpson, Proc. Boston Soc. Nat. Hist., vol. 8, 1861, p. 268.
Asteracanthion berylinus A. Agassiz, Proc. Amer. Acad. Arts Sci., 1863.
Asterias forbesii Verrill, Proc. Boston Soc. Nat. Hist., vol. 10, 1866, p. 345.—Clark, Bull. U. S. Fish Comm. for 1902, p. 552, pl. 1, figs. 1, 2; pl. 4, figs. 14, 15.
Asteracanthion novae boracensis Perrier, Pèdicellaires, 1869, p. 41, pl. 1, fig. 9*a*.

Maine to Gulf of Mexico; low water to 27 fathoms.

5. ASTERIAS RUBENS Linnaeus.

Asterias rubens Linnaeus, Syst. Nat. ed. 10, 1758, p. 661; ed. 12, 1766, p. 1099. For synonymy: Perrier, 1875, p. 47 under *rubens* and *violacea;* Sladen, 1889, p. 572; Bell, Catalogue, 1892, p. 100. Synonyms: *Asterias clathrata* Pennant, 1777; *Asterias* *glacialis* PENNANT, 1777 (not Linnaeus); *Asterias violacea* O. F. MÜLLER, 1788; *Asterias holsatica* RETZIUS, 1805; *Asterias minuta* RETZIUS, 1805; *Asteracanthium distichum* BRANDT, 1851; *Asterias murrayi* BELL. Various combinations of the above names under *Asteracanthion, Asteracanthium, Stellonia, Uraster.*

From the White Sea and Iceland (but not Greenland) down to the Senegal coast; exceedingly common all around the British coasts. Accidentally in the Mediterranean at Cette. From upper tide level to about 400 meters; exceptionally as much as 650 meters. (Mortensen, 1927.)

6. ASTERIAS VERSICOLOR Sladen.

Asterias versicolor SLADEN, 1889, p. 573, pl. 104, figs. 1–4.

The types were taken in depths of 8 to 50 fathoms off Kobe and Awadji Sima, Japan. I have examined the specimens from *Challenger* station 233, off Kobe. The species is obviously related to *amurensis*, but appears to be perfectly distinct from both *amurensis* and *rollestoni*. It will not be strange however if *versicolor* is found to intergrade with *rollestoni*. The general color is yellowish mottled with brown. Each abactinal spine is the center of a yellowish zone. The crossed pedicellariae and the straight pedicellariae are very slender. Sladen's figures are excellent.

7. ASTERIAS VULGARIS Verrill.

Asterias vulgaris VERRILL, Proc. Boston Soc. Nat. Hist., vol. 10, 1866, p. 347.—CLARK, U. S. Fish Comm. Bull. for 1902, p. 533, pl. 1, figs. 3, 4; pl. 4, figs. 16, 17.

Asterias stimpsoni VERRILL (part), Proc. Boston Soc. Nat. Hist., vol. 10, 1866.

Asterias rubens GOULD, 1841; *Asteracanthion rubens* DESOR, 1848; *Asteracanthion violaceus* STIMPSON, 1853; *Asteracanthion rubens* STIMPSON, 1853; *Asteracanthion pallidus* A. AGASSIZ, 1863 (nomen nudum); *Asterias vulgaris* PACKARD, 1863 (nomen nudum); *Asterias fabricii* PERRIER 1875, p. 56; *Asterias pallida* GOTO, 1898.

In shallow water, this species ranges from Labrador to the eastern part of Long Island Sound, while in deep water it continues on to the neighborhood of Cape Hatteras. Low tide to 358 fathoms, exceptionally to 633 fathoms (lat. 39° 15′ N., long. 72° W., *Arcturus* expedition).

Genus EVASTERIAS Verrill, p. 139

1. EVASTERIAS ECHINOSOMA Fisher, p. 152.
2. EVASTERIAS TROSCHELII (Stimpson), p. 139.
   —— forma TROSCHELII, p. 141.
   —— forma ALVEOLATA Verrill, p. 144.
   —— forma ACANTHOSTOMA Verrill, p. 148.

Genus GASTRASTER Perrier

Gastraster PERRIER, Expéd. sci. Travailleur et Talisman, 1894, p. 103. Type, *Pedicellaster margaritaceus* PERRIER, 1882.—FISHER, 1923, p. 596.—MORTENSEN, 1927, p. 137.

Diagnosis.—Abactinal plates relatively large, imbricated in three very regular longiseries; abactinal and superomarginal spinelets small, spaced, delicate; inferomarginal plates with an oblique series of three or four very flat, bladelike spines which form a prominent fringe along edge of ray; superomarginals broader than inferomarginals and abactinal plates, strongly imbricated, four lobed, bearing a crescent of small spinelets; actinal plates small, one corresponding to each inferomarginal; adambulacrals diplacanthid, the spines without attached pedicellariae; first adambulacrals not in contact behind mouth plates; the latter flare a little at inner ends and carry two suborals and a tiny lateral marginal spinelet; a few scattered very small crossed pedicellariae; and a few very small broadly lanceolate straight pedicellariae on actinal surface; tube feet biserial proximally.

The type and only known species is an immature form, which, when adult, may lose the primitive character of the skeleton especially of the mouth angle.

The relationships of the genus are obscure. Perrier placed it in the *Pedicellasteridae* while Mortensen believes it is nearer *Stichaster*. As it stands, it is as isolated as *Stichastrella* and *Neomorphaster*.

GASTRASTER MARGARITACEUS (Perrier).

Pedicellaster margaritaceus PERRIER, Rapport sur la Faune sous-marine de A. Milne Edwards, 1882, p. 50.

Gastraster margaritaceus PERRIER, 1894, p. 103, pl. 9, fig. 3.—MORTENSEN, 1927, p. 137.

I have examined the type specimen, R 17.5 mm.

Off the Azores; Bay of Biscay 938 to 1,225 meters; taken also at 53° 07′ N., 14° 50′ W., 738 to 900 meters (Mortensen),

Genus LEPTASTERIAS Verrill, p. 23

Subgenus LEPTASTERIAS Verrill, p. 24

1. LEPTASTERIAS ARCTICA (Murdoch), p. 24.
—— forma ARCTICA, p. 26.
—— forma BERINGENSIS, p. 27.
2. LEPTASTERIAS AUSTERA (Verrill).

Asterias austera VERRILL, Amer. Journ. Sci., vol. 49, 1895, p. 209.

George's Bank, off Cape Cod, 33 to 35 fathoms (Verrill).

3. LEPTASTERIAS FISHERI Djakonov, p. 42.
4. LEPTASTERIAS GROENLANDICA (Lütken), p. 45.
—— forma GROENLANDICA, p. 48.
—— forma CRIBRARIA, p. 47.

5. LEPTASTERIAS HISPIDELLA Verrill.

Leptasterias hispidella VERRILL, Amer. Journ. Sci., vol. 49, 1895, p. 210.

Albatross Station 2494, 45° 14′ 30″ N., 59° 06′ 45″ W. (off Nova Scotia), 50 fathoms.

"Allied to *L. littoralis* but has much longer and very acute spines, which are less numerous." (Verrill.)

6. LEPTASTERIAS HYLODES Fisher, p. 35.
7. LEPTASTERIAS HYPERBOREA Danielssen and Koren.

Asterias hyperborea DANIELSSEN AND KOREN, Nyt Mag. for Naturvidensk, vol. 27, 1882, p. 269; Norwegian North Atlantic Exp., 1884, p. 10, pl. 3, figs. 1–7.

Asterias normani DANIELSSEN AND KOREN, Nyt Mag. for Naturvidensk, vol. 28, 1883, p. 1, pls. 1, 2, figs. 1–9.

? *Asterias mülleri* var. *floccosa* LEVINSEN, Kara-Havets Echinodermata, 1886.

Vicinity of Spitzbergen; to 35 fathoms (see von Hofsten, 1915, p. 63); Baffin Bay, 98 fathoms (see p. 34). Exclusively high arctic.

8. LEPTASTERIAS LEPTALEA Verrill, p. 44.
9. LEPTASTERIAS LITTORALIS (Stimpson).

Asteracanthion littoralis STIMPSON, Invert. Grand Manan, 1853, p. 14. (Grand Manan, Bay of Fundy.)

Asterias littoralis VERRILL, Proc. Boston Soc. Nat. Hist., vol. 10, 1866, p. 349.

Leptasterias littoralis Verrill, Prelim. Check List of the Marine Invertebrata of the Atlantic Coast, from Cape Cod to the Gulf of St. Lawrence. New Haven, 1879, p. 14.

Casco Bay, Me., to Gulf of St. Lawrence; low tide to 23 fathoms. Allied to *mülleri*.

10. LEPTASTERIAS MÜLLERI (Sars).

Asterias hispida Pennant, British Zoology, vol 4, 1777, pl. 30, fig. 58 (according to Mortensen).

Stellonia hispida Forbes, Mem. Wern. Soc., vol. 8, 1833, p. 123.

Uraster hispida Forbes, British Starfishes, 1841, p. 95.

Asteracanthion mülleri Sars, Archiv f. Naturges., vol. 10, 1844, p. 169; Fauna litt. Norveg., 1 Heft, 1846, p. 56, pl. 8, figs. 38–43.

Asterias mülleri Norman, Ann. Mag. Nat. Hist., ser. 3, vol. 15, 1865, p. 127. For literature see Ludwig, Fauna Artica, vol. 1, 1900, p. 481.

Leptasterias mülleri Verrill, Proc. Boston Soc. Nat. Hist., vol. 10, 1866, p. 350.

North Sea, Irish Sea, southwest Ireland; Shetland Islands; Iceland; Scandinavian coasts. The arctic records of *mülleri* (Spitzbergen, Greenland, Siberian Sea) probably apply to *hyperborea;* while those of boreal waters from Maine northward, to *L. tenera*, or allied forms.

11. LEPTASTERIAS OCHOTENSIS Brandt, p. 57.
12. LEPTASTERIAS OCHOTENSIS SIMILISPINIS (Clark.)

Asterias similispinis H. L. Clark, Bull. Mus. Comp. Zoöl., vol. 51, no. 11, 1908, p. 288 (Taraku Island, Hokkaido, Japan).

Boreal waters of Japan.

13. LEPTASTERIAS ORIENTALIS Djakonov, p. 40.
14. LEPTASTERIAS TENERA (Stimpson).

Asterias tenera Stimpson, Proc. Boston Soc. Nat. Hist., vol. 8, 1862, p. 269.

Asterias compta Stimpson, Proc. Boston Soc. Nat. Hist., vol. 8, 1862, p. 270.

Asteracanthion flaccida Agassiz, 1863.

Leptasterias compta Verrill, Proc. Boston Soc. Nat. Hist., vol. 10, 1866, p. 350.

Leptasterias tenera Verrill, Amer. Journ. Sci., vol. 7, 1874, p. 504.

—— forma TENERA (Stimpson).

Cape Cod to Newfoundland, 10 to 129 fathoms.

—— forma COMPTA (Stimpson).

Atlantic coast of North America from north latitude 37° 19′ to 45° 29′; 10 to 100 fathoms. Large and abundant in the cold areas south of Rhode Island and Marthas Vineyard, in 20 to 50 fathoms (Verrill).

Subgenus HEXASTERIAS Fisher, p. 59

15. LEPTASTERIAS AEQUALIS (Stimpson), p. 120.
—— forma AEQUALIS, p. 123.
—— forma NANA Verrill, p. 123.
16. LEPTASTERIAS ALASKENSIS (Verrill), p. 124.
—— forma ALASKENSIS, p. 125.
—— forma SHUMAGINENSIS Fisher, p. 128.
—— forma PRIBILOFENSIS Fisher, p. 129.
17. LEPTASTERIAS ALASKENSIS ASIATICA Fisher, p. 131.
18. LEPTASTERIAS ALASKENSIS MULTIPSINA Fisher, p. 133.
19. LEPTASTERIAS ALEUTICA Fisher, p. 101.
20. LEPTASTERIAS ASTEIRA Fisher, p. 103.
21. LEPTASTERIAS CAMTSCHATICA (Brandt), p. 91.

22. **LEPTASTERIAS CAMTSCHATICA DISPAR** Verrill, p. 94.
    —— forma **NITIDA** Fisher, p. 95.
    —— forma **NESIOTIS** Fisher, p. 96.
    —— forma **DISPAR**, p. 97.
23. **LEPTASTERIAS COEI** Verrill, p. 84.
24. **LEPTASTERIAS COEI TRUCULENTA** Fisher, p. 86.
25. **LEPTASTERIAS HEXACTIS** (Stimpson), p. 107.
    —— forma **HEXACTIS**, p. 109.
    —— forma **ASPERA** Fisher, p. 110.
    —— forma **REGULARIS** Verrill, p. 111.
    —— forma **SIDEREA** Verrill, p. 112.
    —— forma **PLENA** Verrill, p. 113.
26. **LEPTASTERIAS HEXACTIS VANCOUVERI** (Perrier), p. 115.
27. **LEPTASTERIAS LEPTODOMA** Fisher, p. 105.
28. **LEPTASTERIAS POLARIS** (Müller and Troschel), p. 60.
    —— forma **POLARIS**, p. 60.
    —— forma **SUBACERVATA** Fisher, p. 60.
29. **LEPTASTERIAS POLARIS BOREALIS** (Perrier), p. 61.
30. **LEPTASTERIAS POLARIS ACERVATA** (Stimpson), p. 62.
    —— forma **APHELONOTA** Fisher, p. 63.
    —— forma **ACERVATA**, p. 66.
    —— forma **POLYTHELA** (Verrill), p. 71.
31. **LEPTASTERIAS POLARIS KATHERINAE** (Gray), p. 77.
32. **LEPTASTERIAS PUSILLA** Fisher, p. 118.

Subgenus NESASTERIAS Fisher, p. 135

33. **LEPTASTERIAS STOLACANTHA** Fisher, p. 135.

Genus PISASTER Müller and Troschel, p. 162

1. **PISASTER BREVISPINUS** (Stimpson), p. 180.
    —— forma **BREVISPINUS**, p. 181.
    —— forma **PAUCISPINUS** (Stimpson), p. 184.
2. **PISASTER GIGANTEUS** (Stimpson), p. 172.
3. **PISASTER GIGANTEUS CAPITATUS** (Stimpson), p. 177.
4. **PISASTER OCHRACEUS** (Brandt), p. 164.
    —— forma **CONFERTUS** (Stimpson), p. 168.
    —— forma **OCHRACEUS**, p. 165.
    —— forma **NODIFERUS** Verrill, p. 169.
5. **PISASTER OCHRACEUS SEGNIS** Fisher, p. 171.

Genus STENASTERIAS Verrill, p. 138.

1. **STENASTERIAS MACROPORA** (Verrill), p. 138.

Genus STEPHANASTERIAS Verrill, p. 156

1. **STEPHANASTERIAS ALBULA** (Stimpson), p. 157.
2. **STEPHANASTERIAS GRACILIS** (Perrier).

Asterias gracilis PERRIER, Bull. Mus. Comp. Zoöl., vol. 9, no. 1, 1881, p. 4; Nouv. Arch. du Mus. d'Hist. Nat., vol. 6, 1884, p. 204.

Stephanasterias gracilis VERRILL, Trans. Conn. Acad., vol. 10, 1899, p. 223; West Indian Starfishes, 1915, p. 25, pl. 9, figs. 2–2*c*.

Lesser Antilles, Gulf of Mexico off Florida and off Havana; off east coast of Florida; 56 to 200 fathoms.

Genus STICHASTRELLA Verrill

Stichastrella VERRILL, Shallow-water Starfishes, 1914, p. 40.—FISHER, 1923, p. 597. Type, *Asterias rosea* O. F. Müller.

Diagnosis.—Plates small, with numerous, small, granuliform, close-set spinelets; general appearance suggesting *Henricia;* abactinal skeleton close-knit with small papular areas, rather irregularly distributed dorsolaterally but in definite marginal and actinal longiseries; actinal plates in two or three series; carinals regular; superomarginals slightly broader than inferomarginals; crossed pedicellariae surrounding papular areas, not in circlets around spinelets; adambulacral plates with transverse series of three or four spines proximally, usually three distally, all devoid of attached pedicellariae.

1. STICHASTRELLA ROSEA (O. F. Müller).

Asterias rosea O. F. Müller, Zool. Dan. Prod. 1776, p. 234.

Stichaster roseus M. Sars, Oversigt af Norges Echinodermer, 1861, p. 86.

Stichaster roseus var. *ambiguus* Farran, Fisheries Ireland; Sci. Invest., 1912, no 6 (1913), p. 12, pl. 2, fig. 3.

Stichastrella rosea Verrill, 1914, p. 40.

Bay of Biscay to Lofoten on the Norwegian coasts; British Isles; 4 to 430 meters (Mortensen).

—— forma AMBIGUA (Farran).

Off southwest Ireland, 400 to 1,300 meters.

Genus TARSASTROCLES Fisher

Tarsastrocles Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 12, 1923, pp. 597, 605. Type, *Hydrasterias verrilli* Fisher.

Diagnosis.—See key, p. 5.

1. TARSASTROCLES VERRILLI (Fisher).

Hydrasterias verrilli Fisher, U. S. Fish Comm. Bull. for 1903, pt. 3, 1906, p. 1106, pl. 41, figs. 3, 3*a*, 3*b*.

Hawaiian Islands, 284 to 290 fathoms.

Subfamily Notasteriinae Fisher

Genus ICASTERIAS Fisher

Icasterias Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 12, p. 601. Type, *Asterias panopla* Stuxberg.

Diagnosis.—Abactinal skeleton very weak, irregularly reticulate, sometimes degenerated into more or less disconnected plates; a definite series of carinal plates bearing acicular spines; a few dorsolateral isolated spines; marginals smaller than in *Urasterias;* superomarginals monacanthid; inferomarginals diplacanthid or sporadically monacanthid; a *longiseries of spineless oblong intermarginal ossicles;* adambulacrals diplacanthid; no actinals; crossed pedicellariae smaller than in *Urasterias*, with relatively stouter jaws, scattered thickly over the abactinal and lateral surfaces, but not in wreaths or clusters on the abactinal, marginal, or adambulacral spines; gonads opening just above superomarginal plates a short distance from base of ray.

1. ICASTERIAS PANOPLA (Stuxberg).

Asterias panopla Stuxberg, Öfversigt af Kungl. Vetensk Akad. Förhandl., 35te Argang, no. 3, 1878, p. 32.—Danielssen and Koren, 1884, p. 17, pl. 5.—von Hofsten, 1915, p. 68.

Asterias panopla vars. *brevimana, gracilis, inermis* Kalischewsky, 1907, p. 46.

Arctic; both coasts of Greenland, Spitzbergen, Barents Sea, Kara Sea, eastward to longitude 114° 35′ E.; 18 to 560 meters (von Hofsten).

Genus URASTERIAS Verrill

Urasterias Verrill Amer. Journ. Sci., vol. 28, 1909, p. 67; 1914, pp. 51, 187. Type, *Asteracanthion linckii* Müller and Troschel. Fisher, 1923, pp. 249, 599, 600.

Diagnosis.—Large Notasteriinae with a weak abactinal skeleton consisting of small lobed plates united by slender ossicles into an irregular, loose, open reticulum; marginal plates conspicuously larger than dorsolateral, the superomarginals often trilobate proximally with a long descending process; carinal and dorsolateral spines acicular, isolated, usually without but sometimes with wreaths of crossed pedicellariae; crossed pedicellariae very large and of an unusual form, with slender serrate jaws terminating in an unexpanded unguiculate tip; marginal spines prominent, acicular, one to a plate, the inferomarginals with a very large cluster or cushion and the superomarginals with a wreath of crossed pedicellariae; very numerous, large, compressed-ovoid, straight pedicellariae; gonads opening just above superomarginal plates in interbrachial angle; actinals absent (or extremely rudimentary); adambulacral plates predominantly diplacanthid, the spines normally devoid of attached pedicellariae, although these, on peduncles attached to plates, are numerous on furrow margin.

1. URASTERIAS LINCKII (Müller and Troschel).

Asteracanthion linckii Müller and Troschel, 1842, p. 18.
Asteracanthion stellionura Perrier, 1869, p. 48, pl. 1, fig. 10.
Asterias gunneri Danielssen and Koren, Nyt Mag. Naturvid., vol. 27, p. 268; 1884, p. 7, pl. 2; pl. 3, figs, 8, 9.
Asterias lincki var. *robusta* et var. *sibirica* Kalischewsky, 1907, p. 51.
Urasterias linckii Verrill, 1909, p. 67; 1914, p. 52.

Spitzbergen; Greenland; Nova Scotia; Arctic Ocean from Norway to New Siberia Islands; 5 to 280 meters (von Hofsten, 1915, p. 66).

2. URASTERIAS ENOPLA (Verrill).

Asterias enopla Verrill, Distribution of the Echinoderms of Northeastern America, Amer. Journ. Sci., vol. 49, 1895, p. 208.

Off Nova Scotia, 53 to 100 fathoms.

Possibly a young *linckii*.

Subfamily NEOMORPHASTERINAE Fisher

Genus NEOMORPHASTER Sladen

Neomorphaster Sladen, Challenger Asteroidea, 1889, p. 436. Type, *N. eustichus* Sladen.—Fisher, 1923, p. 596.
Calycaster Perrier, Comptes-rend., 1891, p. 1226; Mem. Soc. Zool., vol. 4, 1891, p. 258. Type, *C. monoecus* Perrier.

Diagnosis.—Abactinally resembling *Zoroaster;* primary plates of disk forming a regular rosette; abactinals and marginals sparsely granulated, imbricated in seven very regular longiseries (and in regular transeries as well), with large papulae at the corners, also in longiseries; two or three series of actinal plates each carrying two or three short, somewhat flattened spinelets; adambulacrals diplacanthid, the spines without attached pedicellariae; adoral carina composed of three or four pairs of postoral adambulacrals; tube feet quadriserial proximally, biserial at end of ray; small crossed pedicellariae scattered on sides and abactinal surface; one or two straight pedicellariae on inner edge of every second adambulacral.

1. NEOMORPHASTER TALISMANI Perrier.

Stichaster talismani Perrier, Ann. sci. nat., vol. 19, art. 8, 1885, fig. 22.
Neomorphaster eustichus Sladen, 1889, p. 438, pl. 66, figs, 3, 4; pl. 68, figs. 9, 10.
Calycaster monoecus Perrier, Mem. soc. zool. France, vol. 4, 1891, p. 262; Rés campag. sci. Prince de Monaco, fasc. 11, 1896, p. 28, pl. 2, figs. 2, 2*a*; pl. 3, figs. 3, 3*a*.

Bay of Biscay; Azores; off the coast of Morocco; southwest of Ireland; 400 to 2,000 meters, exceptionally to 5,413 meters. (Mortensen, 1927.)

2. NEOMORPHASTER FORCIPATUS Verrill.

Neomorphaster forcipatus Verrill, Proc. U. S. Nat. Mus., vol. 17, 1894, p. 269; Amer. Journ. Sci., vol. 49, 1895, p. 206.

Off Georges Bank and south of Marthas Vineyard, 852 to 990 fathoms.

I have examined No. 11131, U.S.N.M., listed by Verrill as one of his types. Verrill writes (1894, p. 270) that there are "attached to the adambulacral spines and in the ventral interradial spaces many acute, ovate, forcipate [straight] pedicellariae, often mixed with crossed pedicellariae and scarcely exceeding the latter in size." I find *no pedicellariae whatsoever attached to the adambulacral spines* which are two to each plate. On the furrow face of alternate adambulacral plates are single small straight pedicellariae or groups of two and three. I find no actinal interradial straight pedicellariae but crossed ones larger than the lateral and dorsal. This species appears to be a typical *Neomorphaster.*

The broad carinals are flanked by a single series of much narrower dorsolaterals; these are followed by superomarginals as broad as the carinals; then a row of inferomarginals about as broad as the dorsolaterals; then a row of actinals, on the side of ray proximally and forming the ventrolateral border distally. Between these and the adambulacrals are two short rows of ventral actinals, the outer scarcely reaching middle of ray, and each plate bearing three or two spines, as do the distal plates of the lateral actinal series (which distally defines the actinolateral margin of ray).

LIST OF SPECIES AND VARIETAL NAMES APPLIED TO ASTERIINAE, NOTASTERIINAE, AND NEOMORPHASTERINAE OF THE NORTHERN HEMISPHERE

In the first column is given the species and original describer; in the second column, the original genus and date; in the third column, the genus to which the species has been assigned in the foregoing summary.

Valid species and forma names are in roman; synonyms in italics.

acanthostoma Verrill	Asterias, 1909	Evasterias.
acervata Stimpson	Asterias, 1862	Leptasterias.
aequalis Stimpson	Asterias, 1862	Leptasterias.
alaskensis Verrill	Asterias, 1909	Leptasterias.
albertensis Verrill	Parasterias, 1914	Asterias.
albulus Stimpson	Asteracanthion, 1853	Stephanasterias.
alveolata Verrill	Evasterias, 1914	Evasterias.
ambiguus Farran	Stichaster, 1913	Stichastrella.
amurensis Lütken	Asterias, 1871	Asterias.
anomala Verrill	Allasterias, 1909	Asterias.
arctica Murdoch	Asterias, 1885	Leptasterias.

arcticus Danielssen and Koren	Stichaster, 1884.	
arenicola Stimpson	Asterias, 1862	Asterias.
austera Verrill	Asterias, 1895	Leptasterias.
australis Verrill	Pisaster, 1914	Pisaster.
berylinus Agassiz	Asteracanthion, 1863	Asterias.
borealis Perrier	Asterias, 1875	Leptasterias.
brachiata Perrier	Asterias, 1875	Evasterias.
brevimana Kalischewsky	Asterias, 1907	Icasterias.
brevispina Stimpson	Asterias, 1857	Pisaster.
camtschatica Brandt	Asterias, 1835	Leptasterias.
capitata Stimpson	Asterias, 1862	Pisaster.
carinella Verrill	Leptasterias, 1914	Leptasterias.
clathrata Pennant	Asterias, 1777	Asterias.
coei Verrill	Leptasterias, 1914	Leptasterias.
compacta Verrill	Leptasterias, 1914	Leptasterias.
compta Stimpson	Asterias, 1866	Leptasterias.
concinna Verrill	Leptasterias, 1914	Leptasterias.
conferta Stimpson	Asterias, 1862	Pisaster.
cribraria Stimpson	Asterias, 1862	Leptasterias.
densa Verrill	Evasterias, 1914	Evasterias.
dispar Verrill	Leptasterias, 1914	Leptasterias.
distichum Brandt	Asteracanthium, 1851	Asterias.
douglasi Perrier	Asterias, 1875	Leptasterias.
dubia Verrill	Asterias, 1909	phantom.
echinosoma Fisher	Evasterias, 1926	Evasterias.
enopla Verrill	Asterias, 1895	Urasterias.
epichlora Brandt	Asterias, 1835.	
exquisita deLoriol	Asterias, 1887	Pisaster.
eustichus Sladen	Neomorphaster, 1889	Neomorphaster.
fabricii Perrier	Asterias, 1875	Asterias.
fisheri Djakonov	Leptasterias, 1929	Leptasterias.
fissispina Stimpson	Asterias, 1862	Pisaster.
flaccida A. Agassiz	Asteracanthion, 1863	Leptasterias.
floccosa Levinsen	Asterias, 1886	Leptasterias.
forbesi Desor	Asteracanthion, 1848	Asterias.
forcipatus Verrill	Neomorphaster, 1894	Neomorphaster.
forficulosa Verrill	Allasterias, 1914	Asterias.
glacialis Pennant	Asterias, 1777	Asterias.
gigantea Stimpson	Asterias, 1862	Pisaster.
gracilis Perrier	Asterias, 1881	Stephanasterias.
gracilis Kalischewsky	Asterias, 1907	Icasterias.
grayi Verrill	Pisaster, 1914	phantom species.
groenlandicus Lütken	Asteracanthion, 1857	Leptasterias.
gunneri Danielssen and Koren	Asterias, 1882	Urasterias.
hexactis Stimpson	Asterias, 1861	Leptasterias.
hispida Pennant	Asterias, 1777	Leptasterias.
hispidella Verrill	Leptasterias, 1895	Leptasterias.
holsatica Retzius	Asterias, 1805	Asterias.
hyperborea Danielssen and Koren	Asterias, 1882	Leptasterias.
inequalis Verrill	Leptasterias, 1914	Evasterias.
inermis Bell	Asterias, 1881	Leptasterias.
inermis Kalischewsky	Asterias, 1907	Icasterias.
islandica Levinsen	Asterias, 1887	Leptasterias.
janthina Brandt	Asterias, 1835	Pisaster.

japonica Bell	Asterias, 1881	Aphelasterias.
katherinae Gray	Asterias, 1840	Leptasterias.
leptalea Verrill	Leptasterias, 1914	Leptasterias.
linckii Müller and Troschel	Asteracanthion, 1842	Urasterias.
littoralis Stimpson	Asteracanthion, 1853	Leptasterias.
longimana Kalischewsky	Asterias, 1907	Leptasterias.
lütkenii Stimpson	Asterias, 1861	Pisaster.
macouni Verrill	Leptasterias, 1914	Evasterias.
macropora Verrill	Asterias, 1909	Stenasterias.
margaritaceus Perrier	Pedicellaster, 1882	Gastraster.
margaritifer Müller and Troschel	Asteracanthion, 1842	Pisaster.
merriami Verrill	Orthasterias, 1914	Leptasterias?.
mexicanum Lütken	Asteracanthion, 1859	Leptasterias.
migratum Sladen	Asteracanthion, 1879	Asterias.
miliaris Verrill	Leptasterias, 1914	Leptasterias.
minuta Fabricius	Asterias, 1780	Leptasterias.
minuta Retzius	Asterias, 1805	Asterias.
monoecus Perrier	Calycaster, 1891	Neomorphaster.
mülleri Sars	Asteracanthion	Leptasterias.
multiclava Verrill	Asterias, 1914	Leptasterias.
murrayi Bell	Asterias	Asterias.
nana Verrill	Leptasterias, 1914	Leptasterias.
nautarum Bell	Asterias (p. 24)	Leptasterias.
nitida Verrill	Stichaster, 1866	Stephanasterias.
nodiferus Verrill	Pisaster, 1914	Pisaster.
normani Danielssen and Koren	Asterias, 1883	Leptasterias.
nortonensis Verrill	Allasterias, 1909	Asterias.
novaeboracensis Perrier	Asteracanthion, 1869	Asterias.
oblecta Verrill	Leptasterias, 1914	Leptasterias.
ochotense Brandt	Asteracanthium, 1851	Leptasterias.
ochracea Brandt	Asterias, 1835	Pisaster.
orientalis Djakonov	Leptasterias, 1929	Lepatsterias.
pallidus A. Agassiz	Asteracanthion, 1863	Asterias.
panopla Stuxberg	Asterias, 1878	Icasterias.
papulosa Verrill	Asterias (Pisaster), 1909	Pisaster.
parvispina Verrill	Evasterias, 1914	Evasterias.
paucispina Stimpson	Asterias, 1862	Pisaster.
pectinata Brandt	Asterias, 1835	Asterias.
philippii Bell	Asterias, 1881	Leptasterias.
plena Verrill	Leptasterias, 1914	Leptasterias.
polaris Müller and Troschel	Asteracanthion, 1842	Leptasterias.
polythela Verrill	Asterias, 1914	Leptasterias.
problema Steenstrup	Asteracanthion, 1857	Stephanasterias.
pugetana Verrill	Leptasterias, 1914	Leptasterias.
pycnopodia Fisher	Aphanasterias, 1923	Aphanasterias.
rathbuni Verrill	Allasterias, 1909	Asterias.
regularis Verrill	Leptasterias, 1914	Leptasterias.
robusta Kalischewsky	Asterias, 1907	Urasterias.
rollestoni Bell	Asterias, 1881	Asterias.
rosea O. F. Müller	Asterias, 1776	Stichastrella.
rubens Linnaeus	Asterias, 1758	Asterias.
rudis Verrill	Evasterias, 1914	Evasterias.
saanichensis deLoriol	Asterias, 1897	Evasterias.
satsumana Döderlein	Asterias, 1902	

segnis Fisher	Pisaster, 1926	Pisaster.
sibirica Kalischewsky	Asterias, 1907	Urasterias.
siderea Verrill	Leptasterias, 1914	Leptasterias.
similispinis Clark	Asterias, 1908	Leptasterias.
spinosa Say	Asterias, 1825 (part)	Asterias.
spitzbergensis Danielssen and Koren	Asterias, 1884	Leptasterias.
stellionura Perrier	Asteracanthion, 1869	Urasterias.
stimpsoni Verrill	Asterias, 1866	Asterias.
subnodosa Verrill	Evasterias, 1914	Evasterias.
subnodulosa Verrill	Leptasterias, 1914	Evasterias.
subregularis Verrill	Leptasterias, 1914	Leptasterias.
talismani Perrier	Stichaster, 1885	Neomorphaster.
tenera Stimpson	Asterias, 1861	Leptasterias.
torquata Sladen	Asterias, 1889	Aphelasterias.
troschelii Stimpson	Asterias, 1861	Evasterias.
vancouveri Perrier	Asterias, 1875	Leptasterias.
verrilli Fisher	Hydrasterias, 1906	Tarsastrocles.
versicolor Sladen	Asterias, 1889	Asterias
victoriana Verrill	Asterias, 1909	Evasterias.
violacea O. F. Müller	Asterias, 1788	Asterias.
vulgaris Verrill	Asterias, 1863	Asterias.

SUMMARY OF THE GENERA AND SPECIES OF ASTERIINAE AND NOTASTERIINAE OF THE SOUTHERN HEMISPHERE

The following synopsis is not intended to be a revision in the usual sense, since I have not had sufficient material for such an undertaking. It is an attempt to set in order the species of Asteriinae known to occur in the Southern Hemisphere, particularly in antarctic and subantarctic regions. I have also essayed to define more sharply a number of genera which are still poorly understood.

Diplasterias Perrier has been resuscitated for *Asterias brandti* and near relatives. There seems to be no alternative under existing rules of nomenclature but to recognize this name and to discard *Podasterias* which was first used by Perrier for a *Cosmasterias*, then for *Diplasterias;* later by Koehler (1912) for *Diplasterias spinosa;* still later by Verrill (1914) for *Diplasterias* (part).

So far as known no genus of southern Asteriinae and Notasteriinae is represented (at least well authenticated) in the Northern Hemisphere.

The following species have not been assigned a place in the summary.

Cosmasterias radiata Koehler, 1923, p. 36, pl. 2, fig. 5; pl. 3, figs. 1, 2. This species does not seem to me to be congeneric with *Cosmasterias lurida*. It was dredged from Shag Rock Bank between south Georgia and Falkland Islands, 160 meters.

Diplasterias spinosa Perrier, 1891, p. 82. Koehler, 1908, p. 273; 1912, p. 17, pl. 1, figs. 2, 9; 1917, p. 29. This species was assigned to *Podasterias* by Koehler in 1912 as sole species, and in 1917, with hesitation, to *Cosmasterias*. Koehler indicates that there are three longiseries of actinal spines, but an examination of his photograph of the actinal surface in conjunction with Perrier's description suggests rather that the inner series is referable to the actinal plates, while the two outer are on the inferomarginal plates—as in *Diplasterias*. This interpretation and the absence of definite longiserial arrangement of abactinal spines would rule out *Cosmasterias*. The long narrow adoral carina is not found in *Diplasterias*, ss. The species probably represents a new generic group, as Doctor Koehler has already suggested. (1917, p. 29.)

The type and only known specimen was taken latitude 47° 29′ S., longitude 66° 45′ W.

Gastraster studeri de Loriol, 1904, p. 34, pl. 4, figs. 3, 3*a*–3*f*. Verrill, 1914, p. 360. The type is probably a very immature *Cosmasterias lurida* and was taken along with adult *lurida* at Port San Antonio, Gulf of San Mathias, Argentina. It is certainly not congeneric with the type of *Gastraster*, *G. margaritaceus*, which I have examined at the Museum d'Histoire Naturelle.

Asterias borbonica Perrier, 1875, p. 61. The type in the Museum d'Histoire Naturelle carries a label "*Parasterias borbonica*—I Bourbon, 1852." It is now in alcohol but was dried at one time. R. 17 mm., r 5 mm. The specimen probably represents a young *Sporasterias*, but no examination of the gonads was made.

Reunion Island, Indian Ocean, latitude 21° S.

Asterias inermis Bell, Proc. Zool. Soc., 1881, p. 512, pl. 47, figs. 2, 2*a*. The type, supposed to be from Ecuador, is in reality *Leptasterias groenlandica* forma *cribraria*, probably from Bering Sea. (See Fisher, 1926, p. 198.)

Asterias nautarum Bell. Listed by Sladen, 1889, p. 824. The type specimen labeled "Ecuador, Hassler Collection," is *Leptasterias arctica* (Murdoch) and is probably from Bering Sea. (See Fisher, 1926, p. 198, and antea, p. 24.)

Asterias philippii Bell, Proc. Zool. Soc., 1881, p. 511, pl. 47, figs. 1, 1*a*. The two types in the British Museum are labeled "South America, Hassler Coll." These specimens are *Leptasterias polaris acervata* (Stimpson), with a well-developed central spine to each abactinal heap of enlarged granules. They are very nearly identical with Stimpson's type of *Asterias acervata* and undoubtedly came from Bering Sea.

Asterias fragilis Studer, Trans. Roy. Acad. Sci. Berlin, 1884; Farquhar, 1909, p. 127. Farquhar gives a translation of the original description. The type measured R 16½ mm., r 4 mm.; breadth of ray at base, 8 mm. Studer places it next to *Cosmasterias lurida*. It is obviously young. Found east of New Zealand, 35° 21′ S., 175° 40′ E., 597 fathoms.

Asterias (*Smilasterias*) *terwieli* Emilie Goldschmidt, Ann. Mag. Nat. Hist., ser. 9, vol. 14, 1924, p. 499, text figs. 1 to 3. This species does not belong to the Asteriidae.

Subfamily ASTERIINAE Verrill (emended)

KEY TO THE GENERA OF ASTERIINAE OF THE SOUTHERN HEMISPHERE

a^1. Plates of the abactinal surface of ray have the appearance of forming rather definite longitudinal series even when the dorsolaterals are not in regular series (in this case the dorsolateral region is narrow and dominated by the broad carinals and superomarginals); abactinal plates generally with several spinelets or granules, but if with only one spine, then this is small and not conspicuous; adambulacral plates never carry attached pedicellariae singly or in clusters, although straight pedicellariae may occur on oral spines and on furrow margin of adambulacral plates.

  b^1. Adambulacral plates with two spines.

    c^1. Actinal plates in one series (or rudiment of second) dominated by the inferomarginals which form the ventrolateral margin of ray; no large unguiculate straight pedicellariae; crossed pedicellariae scattered, not in clusters of wreaths around abactinal spines; superomarginals conspicuously broader than the inferomarginals.

      d^1. Carinals and superomarginals of exaggerated width in proportion to length; dorsolateral area broad, the plates in three to five series on each side of the carinals; one madreporic body; not fissiparous; superomarginal plates without beaded area on surface; (gonoducts open dorsally, those of male with a proximal swelling; interbrachial septa heavily calcified. Includes *Coelasterias australis* Verrill, 11 rays). **Stichaster** Müller and Troschel.

      d^2. Carinals and superomarginals broader than other plates but not excessively so; dorsolateral area narrow, the plates in a single straight or zigzag series (altogether, three series of abactinal plates); fissiparous; multiple madreporic bodies; superomarginal plates with beaded surface.................................. **Allostichaster** Verrill.

      d^3. Young *Diplasterias* may lead here; see under a^2.

    c^2. Actinal plates in two or more prominent series forming the actinal or the actinal and actinolateral surfaces of ray (and not dominated or overhung by the inferomarginals).

      d^1. Large unguiculate straight pedicellariae; actinostome sunken, the adoral carina long, consisting of more than three pairs of contiguous postoral adambulacral plates. **Cosmasterias** Sladen.

      d^2. No large unguiculate pedicellariae; actinostome not sunken; adoral carina short, consisting of one or two pairs of contiguous postoral adambulacral plates. Plates large with coarse, often capitate, globose spines and tubercles; abactinal skeleton with large, more or less irregular meshes in two dorsolateral series on either side of the irregular carinal series; superomarginals with one to several capitate, stout spines; inferomarginals with one to three spines; one to three series of actinal plates, usually two or three; one well defined though sometimes irregular series of dorsolateral plates; adambulacrals very regularly diplacanthid---------**Uniophora** Gray.

b^2. Adambulacral plates monacanthid; dorsolaterals not very numerous, trilobed, in one or two fairly regular series, more or less concealed by integument; superomarginals very broad; inferomarginals (each bearing an oblique comb of two to four prominent spines) form a sharp ventrolateral border to ray; an inconspicuous series of actinal plates; rays short and thick; gonads open ventrally---------**Calvasterias** Perrier.

a^2. Abactinal skeleton an irregular net with meshes of various sizes, the plates being sometimes closely but irregularly imbricated by their lobes; abactinal plates not in rather obvious longitudinal series (but occasionally in more or less evident transverse series); carinal series usually but not always distinguishable and frequently very irregular; body sometimes covered by a pulpy skin which obscures the plates and sometimes even the spinelets.

b^1. Adambulacral plates with two, rarely three spines, which never carry attached pedicellariae, although large and small straight pedicellariae may occur on the surface of the plates or on fleshy peduncles attached to plates near base of spines; clusters of the latter in dried specimens occasionally appear to spring from the spine-sheath, but in reality do not.

c^1. Abactinal plates and spinelets normally developed; both series of marginal plates normally developed.

d^1. An actinolateral chevaux-de-frise of inferomarginal spines in transverse series of three or four; abactinal spinelets numerous, small, close-set; superomarginal spines small, not forming a well-differentiated, single or double longiseries; pedicellariae scattered, not in circlets at base of spines, nor on sheaths surrounding spines; skin not thick or puffy.

e^1. Actinolateral spines devoid of attached pedicellariae; actinal spines in one series or absent; gonads opening dorsally---------**Smilasterias** Sladen.

e^2. Actinolateral spines carrying pedicellariae; gonads opening ventrally; paedophoric; one series of actinal spines---------**Neosmilaster** Fisher.

d^2. Superomarginal, inferomarginal, and actinal spines forming longiseries with circlets or bouquets of pedicellariae; abactinal crossed pedicellariae associated with spines, in circlets or attached to the base.

e^1. Spinelets slender, mobile, more or less sheathed with soft skin carrying crossed pedicellariae; gonads opening ventrally; young brooded by adult; superomarginals monacanthid or diplacanthid; inferomarginals monacanthid or diplacanthid; one or two series of monacanthid actinal plates (exceptionally spineless); adambulacrals regularly diplacanthid---------**Diplasterias** Perrier.

e^2. Spinelets coarse, tuberculate, sometimes very large, capitate or globose; skin not soft or pulpy; gonads opening dorsally; actinals in one to three series--**Uniophora** Gray.

c^2. Either the superomarginal plates, or those of both series, not easily distinguishable; abactinal skeleton well developed; inferomarginal spines not in close-set transverse series.

d^1. Only the inferomarginals, of the two series, clearly distinguishable; to them are joined small lateral transverse arcs (containing the superomarginals) separated, consecutively, by broad papular areas or skeletal spaces; abactinal skeleton an irregular network of plates, without indication of a carinal series; abactinal and inferomarginal spinelets slender, cylindrical, in small groups; two long adambulacral spines; ambulacral furrows wide, with large 4-ranked tube feet; rays 9 or 10.
Saliasterias Koehler.

d^2. Marginal plates not superficially distinguishable; a close granulation more or less uniform, without serial arrangement, interspersed with scattered pedicellariae, overlies relatively large three to five lobed plates in an irregular abactinal reticulum; marginals four lobed; an incomplete series of actinals; size small; gonads opening ventrally. (Includes *Hemiasterias* Verrill, type *G. biseriatus* Koehler.)
Granaster Perrier.

c^3. Abactinal skeleton weak or else abortive; abactinal integument thick, papillose; no actinal plates.

d^1. Marginal and abactinal plates present; marginal plates well developed; the superomarginals with one spine wreathed with pedicellariae and having long descending processes which form a broad, vertical, intermarginal channel; inferomarginals with two webbed spines (each with a cluster of pedicellariae on outer face); abactinal surface soft, rather irregularly and finely papillose; abactinal plates thin (with rudimentary spinelets only) forming an irregular reticulum entirely concealed by the skin; interbrachial septum strongly calcified; gonads opening ventrally, eggs huge; good sized, broadly lanceolate, straight pedicellariae on furrow margin; two pairs of postoral adambulacral plates contiguous; adambulacral plates regularly diplacanthid---------------------------**Cryptasterias** Verrill.

d^2. Neither marginal nor abactinal plates present, the skeleton reduced to the ambulacral and adambulacral systems. (See sec. a^3.)------------------**Adelasterias** Verrill.

b^2. Adambulacral plates with a single spine, devoid of attached pedicellariae.

c^1. Abactinal skeleton more or less well developed, consisting of lobed and oblong plates united into an open or fairly close meshwork, in which not very regular longiseries can sometimes be distinguished; abactinal spinelets fairly to very numerous; skin typically not unusually thick pulpy and rugose (exceptions); actinal plates in one series (may be absent in young).

d^1. Abactinal and superomarginal spines surrounded by circlets of crossed pedicellariae; inferomarginal and actinal spines cylindrical or clavate, the former, two or three to a plate in an oblique series, with an associated group of crossed pedicellariae; paedophoric---------------------------**Sporasterias** Perrier.

d^2. Pedicellariae rare and scattered, not in circlets around abactinal and superomarginal spinelets; inferomarginal and actinal spines chisel shaped, devoid of pedicellariae, closely coordinated into oblique transverse combs forming a chevaux-de-frise along the actinolateral border of ray; gonads unknown---------------- **Eremasterias** Fisher.

c^2. Skeleton hidden under a pulpy, sometimes very rugose pustulated skin; abactinal skeleton irregularly reticulate, weak, with few spinelets; gonads opening ventrally.

d^1. Skin very thick, complex, pustulated, the abactinal spines being surrounded by the same cauliflower structure; actinals spineless; rays eight or nine; adambulacrals diplacanthid at base of ray---------------------------**Koehleraster** Fisher.

d^2. Skin thick but not having a complex cauliflower structure.

e^1. Both series of marginals well developed------------------------**Anasterias** Perrier.

e^2. Superomarginals weakly developed, forming a rather irregular series and bearing sporadically isolated spinelets------------------------**Kalyptasterias** Koehler.

b^3. Adambulacral plates with a crowded transverse comb of four or five spines (three to six) *which carry attached pedicellariae;* actinal area extensive with three to six longiseries of well-developed 4-lobed, spiniferous plates; mouth angle rather broad, without compressed adoral carina, two or three postoral pairs of adambulacral plates in contact; gonads opening dorsally---------------------------**Perissasterias** Clark.

a^3. Abactinal surface devoid of a connected skeleton, soft and flexible, the abactinal plates, if present, isolated, spaced, and superficially invisible.

b^1. Marginal and abactinal skeleton consisting of lateral spaced, transverse tongues of plates (composed of two reduced marginals plus sometimes one or several abactinals) abutting on the adambulacral plates; dorsal surface with much reduced, disconnected, scattered platelets; dermis thick, surrounding the spinelets in mammillated pustules; adambulacrals monacanthid; gonads opening ventrally. (*Anasterias* authors, not Perrier.)
Lysasterias Fisher.

b^2. Neither marginal nor abactinal plates present, the skeleton reduced to the ambulacral and adambulacral systems; body covered with numerous papillae, containing each a slender spinelet, disposed without order on all surfaces; adambulacrals diplacanthid.
Adelasterias Verrill.

Genus ADELASTERIAS Verrill

Adelasterias Verrill, Shallow-water Starfishes, 1914, p. 360. Type, *Diplasterias papillosa* Koehler.—Fisher, 1923, p. 607.

Diagnosis.—Neither marginal nor abactinal plates present, the skeleton reduced to the ambulacral and adambulacral systems; body covered with numerous papillae, each containing a slender spinelet, disposed without order on all surfaces; adambulacral plates diplacanthid.

1. ADELASTERIAS PAPILLOSA (Koehler).

Diplasterias papillosa Koehler, 1906, p. 21, pl. 1, figs. 2–5; pl. 2, figs. 18, 19; 1912, p. 21.

Graham Land and vicinity, western Antarctica; low tide to 6 meters.

Genus ALLOSTICHASTER Verrill

Allostichaster Verrill, Shallow-water Starfishes, 1914, p. 363. Type, *Asteracanthion polyplax* Müller and Troschel.—Clark, 1916, p. 70.—Fisher, 1923, p. 575.

Diagnosis.—Body covered with small granuliform spinelets; skeleton close-knit, the plates in definite longiseries; carinals and superomarginals broader than other plates; inferomarginals forming ventrolateral edge to ray; dorsolateral area narrow, the plates in a single straight or zigzag series (altogether three series of abactinal plates); one series of actinal plates; inferomarginal plates with oblique transverse series of a few spinelets along ventrolateral margin of ray; cleaned superomarginal plates with minutely beaded surface; adambulacral plates diplacanthid; pedicellariae scattered among spinelets; multiple madreporic bodies; fissiparous; rays six to eight.

1. ALLOSTICHASTER POLYPLAX (Müller and Troschel).

Asteracanthion polyplax Müller and Troschel, Arch. Naturges., 1844, p. 178.
Asterias polyplax Perrier, Rév. Stell., 1875, p. 63.—Clark, Echinoderms Western Australian Mus., 1913, p. 151.
Stichaster polyplax Sladen, 1889, p. 432.—Farquhar, 1897, p. 196; 1898, p. 313; 1909, p. 129.—Benham, 1909, p. 15.
Tarsaster neozealanica Farquhar, Trans. New Zeal. Inst., vol. 27, 1895, p. 207, pl. 12.
Allostichaster polyplax Clark, Biol. Res. Fishing Exper. *Endeavour*, vol. 6, 1916, p. 70.—Koehler, 1920, p. 85, pl. 18, fig. 7–11; pl. 69, fig. 2.—Mortensen, 1925, p. 315, fig. 19*a*,*b*.

Tasmania, Australia, New Zealand.

2. ALLOSTICHASTER INSIGNIS (Farquhar).

Stichaster insignis Farquhar, Trans. New Zeal. Inst., vol. 27, 1895, p. 205, pl. 13, fig. 1; vol. 30, 1898, p. 188; Proc. Linn. Soc. New South Wales, 1898, p. 314.—Benham, 1909, p. 15.
Allostichaster insignis Koehler, 1920, p. 85, pl. 20, figs. 2–7; pl. 65, fig. 2.—Fisher, 1923, p. 595.—Mortensen, 1925, p. 316, fig. 19, *c*, *d*.

New Zealand; Auckland Islands.

3. ALLOSTICHASTER INAEQUALIS Koehler.

Allostichaster inaequalis Koehler, 1923, p. 50, pl. 1, figs. 7, 8; pl. 7, figs. 1–3.

Magellanic region, 7 to 100 meters.

4. ALLOSTICHASTER HARTI (Rathbun).

Leptasterias hartii R. RATHBUN, Echinoderms of Brazil, Trans. Conn. Acad. Sci., vol. 5, 1879, p. 145.—VERRILL, 1915, p. 23.

The type was taken about 30 miles east of Cape Negro, Brazil, in 62 fathoms. I have a specimen from the Museum of Comparative Zoölogy labeled "Patagonia, 44 fathoms" which, like the type, has six rays, and measures R 19 mm., r 3.5 mm. It has one larger and two smaller madreporic bodies.

Another species which probably belongs to *Allostichaster* is *Stephanasterias hebes* Verrill (1915, p. 26, pl. 9, fig. 3), which was taken by the *Albatross* at station 2766, off the east coast of South America (lat. 36° 47′ S., long. 56° 23′ W.). The description is incomplete but the actinal aspect of the ray, as figured, suggests *Allostichaster* rather than *Stephanasterias*. It is possible that the specimen of *hartii* referred to above, really belongs in *hebes*.

5. ALLOSTICHASTER REGULARIS Clark.

Allostichaster regularis CLARK, Rec. South Austral. Mus., vol. 3, No. 4, 1928, p. 400, fig.115.

South Australia: Spencer and St. Vincent Gulfs.

Genus ANASTERIAS Perrier

Anasterias PERRIER, Rév. Stell., 1875, p. 81; 1891, p. 91. Type, *Anasterias minuta* Perrier.—FISHER, Smithsonian Misc. Coll., vol. 52, 1908, p. 52; Zool. Anz., vol. 33, 1908, p. 356; Ann. Mag. Nat. Hist., ser. 9, vol. 10, 1922, p. 592; vol. 18, 1926, p. 197.

Asteroderma PERRIER, Comptes-rend., vol. 106, no. 11,1888, p. 763; Mission sci. Cap Horn, 1891, p. 96.

(Not *Anasterias* Ludwig, 1903; nor Koehler, 1906, 1908, 1912, 1920, 1923; nor Verrill, 1914. See *Lysasterias*.)

Diagnosis.—Resembling *Sporasterias* but the abactinal skeleton typically reduced to an open, delicate irregular mesh, entirely hidden by thick pulpy skin, which in the adult, even when dried, may conceal the underlying plates. Both series of marginal plates well developed; the superomarginals commonly monacanthid (or spineless), the inferomarginals diplacanthid; one series of actinals, sporadically spiniferous; adoral carina composed of about three pairs of contiguous postoral adambulacral plates; interbrachial septum strongly calcified; gonads opening ventrally—paedophoric.

Remarks.—The above diagnosis is intended to characterize two known species of a larger group which includes *Sporasterias* and possibly *Kalyptasterias*, and which by right of priority would be called *Anasterias*. This diagnosis of *Anasterias* is therefore of the subgenus *Anasterias*. The diagnoses of *Sporasterias* and *Kalyptasterias* are also of subgenera. I have listed these groups separately in order to direct attention to the peculiar characters of *Anasterias*, s. s., concerning which there has been some misapprehension.

The generic name *Anasterias* has usually been incorrectly applied since Ludwig first set the fashion in 1903 by using it for a group of small, paedophoric sea stars, almost devoid of abactinal skeleton but characterized by a soft, pustulated, glandular integument. These bear a strong superficial resemblance to *Anasterias minuta* which, on the contrary, has a reticulate abactinal skeleton. Several authors, notably Koehler and Verrill, have followed Ludwig. The genus erroneously called *Anasterias* was named *Lysasterias* by me in 1908.

The type specimen of *Anasterias minuta* was indicated by Perrier in 1891 (p. 93) as that bearing the label "Voyage de l'Astrolabe; M. M. Hombron et Jacquinot," and he gives reasons for believing it to have been collected at Port Famine, Magellan Strait.

In 1923, thanks to the cooperation of Prof. L. Joubin, I examined this specimen at the Museum d'Histoire Naturelle and published some notes on it. [36]

The type specimen of *A. minuta* is in alcohol and is labelled E 792, M. M. Hombron et Jacquinot, 1847. The rays are short. Measurements, according to Perrier, R 12 mm., r 6 mm. The integument entirely conceals the abactinal skeleton. I subjected the abactinal surface of one ray to treatment with potassium hydrate, which revealed a fairly regular series of small carinal plates, between which and the regular inferomarginals (each with one short spinelet) is an irregular, very open, incomplete net of plates, strongest next to the superomarginals. The net is in part composed of about 14 irregular transverse tongues of plates on either side, extending inward toward the carinals and each corresponds roughly to a marginal plate. The inferomarginals have two spines, which are the largest on the body and are separated from the smaller single superomarginal by a fairly broad channel with a row of papulae. Actinals apparently not developed; adambulacral plates strictly monacanthid. The abactinal surface though soft and somewhat pulpy is not papillose in the sense that *Lysasterias* and *Koehleraster* are. Abactinal spinelets are few and scattered.

It is quite necessary to fix the attention on this type specimen of *Anasterias minuta* which establishes the identity of the species and hence of the genus. The specimens of *Anasterias minuta* listed by Perrier in 1891 may or may not be *A. minuta* and have nothing to do with the status of *Anasterias*.

It is a fact that *Anasterias* Perrier has a connected dorsal skeleton, whereas *Anasterias* Ludwig has not; *A. minuta* also lacks the pustulated or papillose abactinal integument which is described as being characteristic of *Anasterias* Ludwig (*Lysasterias* Fisher).

Anasterias Perrier is closely related to *Sporasterias*, as exemplified by *S. antarctica* and its alleged synonym, *S. rugispina* (the genotype). In fact Leipoldt, 1895, synonymized *Anasterias minuta* with *S. antarctica* and *S. rugispina;* while Perrier, himself, writing in 1891,[37] says:

> Les étoiles de mer que j'ai nommées *Anasterias minuta, Asterias rugispina* Stimpson; celles que M. Studer appelle *Asterias antarctica* Lütken; celles que M. Bell a appellées *Asterias spirabilis* sont donc des formes extremement voisines, sinon identiques.

Furthermore Koehler (1920, p. 11) writes:

> Je dois dire que j'ai eu en communication plusieurs *Anasterias minuta* du Jardin des Plantes [but evidently not the type] et j'ai pu constater que toutes étaient parfaitment identiques à de jeunes *Sporasterias antarctica.* J'estime donc l'*A. minuta* forme jeune d'une *Sporasterias* ou peut-être d'une autre *Anasterias,* ne doit pas figurer parmi les èspeces du genre *Anasterias.*

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[36] Notes on the Asteroidea. IV. Ann. Mag. Nat. Hist., ser. 9, vol. 18, 1926, p. 197.

[37] Miss. sci. Cap Horn, p. 15.

It seems to me probable that the type specimen of *A. minuta* is not the young of *antarctica*, nor of any species of *Lysasterias*, because I have examples of an *Anasterias* from the Falkland Islands, which are distinct from *Sporasterias antarctica*, and which I believe to be true *A. minuta*. (See below.) The open, weak, recticular, abactinal skeleton, overlaid by a thick pulpy skin is like that of the type of *A. minuta*.

The species of *Anasterias* and of *Sporasterias* are extremely variable and the two genera appear to me to be confluent. The distinguishing features for *Anasterias* are the weaker, more open, abactinal skeleton and the thicker, pulpy skin, entirely obscuring the abactinal plates and also sometimes the spinelets. But these characters are relative. Some specimens of *Sporasterias* have a *rather* weak, open, abactinal skeleton (especially when young); and a skin obscuring the plates and forming a thick welt around the spinelets is also rather common. I have some specimens collected by Dr. W. L. Schmitt near Teal Inlet, Falkland Islands, which on the basis of skeleton and spinelets are *Sporasterias*, but of dermal characters are *Anasterias*. It is probable that the thicker skin is directly correlated with a weak abactinal skeleton. The formation of local formae is undoubtedly encouraged by the sedentary habits of these sea stars and by their habit of rearing a relatively few young in a temporary suboral brood chamber.

Kalyptasterias conferta Koehler is closely similar to *Anasterias minuta*. A well-hardened alcoholic specimen of the latter resembles the figures of *K. conferta* in Koehler's sea stars of the Swedish Antarctic Expedition (1923, pl. 4, figs. 3 and 4). The principal anatomical difference is in the weaker, less regular, superomarginals of *Kalyptasterias*—a distinction which seems to me to be specific or subgeneric, rather than generic.

In tabular form the species would be arranged as follows:

Genus *Anasterias* Perrier, 1875.

1. Subgenus *Anasterias*—including *A. minuta*, *A. pedicellaris*, and possibly *A. victoriae* Koehler (*Lysasterias victoriae*).
2. Subgenus *Sporasterias* Perrier, 1894—including *A. antarctica*, *A. directa*, *A. mawsoni*, *A. rupicola*, *A. perrieri*, *A. sphaerulata* (see below).
3. Subgenus *Kalyptasterias* Koehler, 1923—including *A. conferta*.

If it should eventually be proven that the type specimen of *Anasterias minuta* is really a young *Sporasterias antarctica*, then obviously the same species is the type of both *Anasterias* and *Sporasterias*. The broader genus would continue to be called *Anasterias*, the oldest name, which would also be the name of the subgenus called *Sporasterias* above. The subgenus *Anasterias* of the present scheme would be called *Asteroderma*, with *A. papillosum* for type (unless it, too, is a young *antarctica*).

I have included the two following forms:

1. ANASTERIAS MINUTA Perrier.

Anasterias minuta PERRIER, Rév. Stell., 1875, p. 81; Mission sci. Cap Horn, 1891, p. 93 (in part).

? *Asteroderma papillosum* PERRIER, Comptes-rend, vol. 106, no. 11, 1888, p. 765; Mission sci. Cap Horn, 1891, p. 96.

? *Asterias minuta* var *Asteroderma papillosum* PERRIER, 1891, pl. 10, fig. 3*a*–3*c*.

Strait of Magellan, Tierra del Fuego, Falkland Islands.

The type of this species is in the Museum d'Histoire Naturelle (E 792 M. M. Hombron et Jacquinot, 1847, alcohol). See antea. Perrier considered the type locality to be Port Famine, Magellan Strait.

Two dried specimens from Darwin Harbor, Choiseul Sound, Falkland Islands (No. 2623 Mus. Comp. Zoöl.) apparently belong to this species. The smaller measures R 18 mm., r 6 mm.; the larger R 48 mm., r 13 mm. In the smaller example the abactinal skeleton is clearly visible and consists of a weak, irregular reticulum resembling the condition in *A. pedicellaris* as figured by Koehler (1923, pl. 5, figs. 1 and 4) and closely similar to that of the type specimen of *minuta*. Most of the superomarginals carry one spinelet and the inferomarginals two, while scattered along the intermarginal channel and inside the furrow margin are rather numerous, lanceolate straight pedicellariae two-thirds the length of the superomarginal spinelets. In the larger specimen, however, the abactinal integument has thickened and conceals the skeleton which is quite weak and irregular as in Koehler's Plate 5, Figure 1, alluded to above. The proportions are about as in Figure 4. There are a few actinal plates and spines at the base of the ray and the adoral carina is composed of three pairs of contiguous adambulacrals, the first pair larger than second, and the second larger than third. The superomarginal spines have been mostly absorbed; pedicellariae as in the small example. A third specimen (No. 2624) carries a cluster of young.

Sixteen specimens from Port Stanley, Falkland Islands, collected in 1927 by Dr. W. L. Schmitt. These are evidently conspecific with the Darwin Harbor examples. A well-hardened alcoholic example (R48 mm.) resembles the *Kalyptasterias conferta* figured by Koehler (1923, pl. 4, figs. 3 and 4). The abactinal plates are slender, delicate, and form an irregular reticulum, with very large meshes, and are entirely hidden, until dried, by the soft pulpy integument. Dorsal spinelets few and widely scattered; only a few abactinal crossed and straight pedicellariae. Superomarginal plates normal, not massive, each with one blunt, terete, slender spinelet, 1 to 1.5 mm. long; inferomarginals with two, decidedly stouter and longer spines; actinal plates with one spine, slightly smaller, the series extending two-thirds length of ray, each spine forming with the inferomarginal spines a transverse series of three. Numerous, rather thickly lanceolate, subobtuse straight pedicellariae, decidedly longer than broad are scattered on the marginal and actinal plates, in the intermarginal channel and along edge of furrow. *No associated cross pedicellariae*, except near end of ray and there only a few. [In *Sporasterias antarctica* the superomarginals are normally surrounded by crossed pedicellariae, and the inferomarginal plates carry at least a few on the intermarginal side of the spines.]

Another lot of nine from Port Stanley (April 16, 1927) differs in having numerous small capitate abactinal spinelets, and fairly numerous abactinal (but not marginal) crossed pedicellariae; straight pedicellariae scattered over abactinal surface and distributed laterally and actinally without associated crossed pedicellariae; integument thick, pulpy, in alcohol. When dried a specimen would pass for an aberrant *Sporasterias antarctica*, with weak dorsal skeleton. One specimen carries a thick mass of eggs in the oral concavity.

Fourteen specimens from near Teal Inlet, Falklands, also collected by Doctor Schmitt, do not belong to this species but are mentioned because they have the thick dorsal integument and abactinal spinelets of the above lot. When dried they resemble *Sporasterias antarctica*, almost devoid of crossed pedicellariae and with only a few straight pedicellariae laterally (but with a series of small ones on furrow margin). In some but not all specimens a few crossed pedicellariae occur sporadically here and there on the upper side of the inferomarginal plates (where there are none in typical specimens of *minuta*). At the present writing I do not know what these are.

I was not able to find a specimen of Perrier's *Asteroderma papillosum* at the Museum d'Histoire Naturelle.

2. ANASTERIAS PEDICELLARIS (Koehler.)

Sporasterias pedicellaris Koehler, Swed. Ant. Exp., vol. 1, no. 1, 1923, p. 18, pl. 5, figs. 1–6; pl. 6, figs. 1–5, 7–10.

Sporasterias antarctica Koehler, 1920, p. 78, pl. 18, fig. 4.

? *Anasterias perrieri* Perrier, Mission sci. Cap Horn, 1891, p. 7 (not Studer, 1885). I have seen a specimen at the Museum d'Histoire Naturelle.

This species is fully described and figured by Koehler. He notes that in some specimens the spines and characteristic pedicellariae may be very slightly developed, or are even lacking. He states also that the external appearance, in respect to the more or less soft consistency of the abactinal wall, resembles that of *Lysasterias*.

Under this nominal species I have tentatively classified several specimens, mostly in a bad state of preservation, which were collected by Dr. W. L. Schmitt at Port Stanley, Falkland Islands. The abactinal spinelets are fairly numerous, and scattered among them are numerous crossed pedicellariae. In contrast to the condition in *minuta*, a few crossed pedicellariae here and there accompany the conspicuous lanceolate pedicellariae of the superomarginal and inferomarginal plates. R 40 mm., r 12 mm.

Koehler's material was taken at Tierra del Fuego, 36 meters, and the Falkland Islands, 7 to 10 meters. Certain specimens collected at low tide, Sparrow Cove, East Falkland, are probably the same as my *minuta*, since "les piquants et les pedicellaires sont très peu développés et ils font même complètement défaut sur certains exemplaires."

It is likely that *pedicellaris* and *minuta* are two "manifestations" of a single species.

Genus CALVASTERIAS Perrier

Calvasterias Perrier, Rév. Stell., 1875, p. 84. Type, *C. asterinoides* Perrier.—Fisher, 1922, p. 597; 1923, p. 597.

Stichorella Koehler, Austral. Ant. Exp., vol. 8, 1920, p. 89. Type, *Stichaster suteri* de Loriol.

Diagnosis.—Broad-rayed, monacanthid, paedophoric species, with the skeleton more of less concealed by smooth integument, and with a rather sharp ventrolateral margin to ray marked by oblique combs of two to four short inferomarginal spines; superomarginals very broad (largest plates of all) bearing one or two granuliform spinelets; dorsolaterals not very numerous, trilobed, in one or two fairly regular longiseries; a definite series of strongly imbricated 4-lobed carinals; abactinal skeleton with only a few granules, or with numerous granules in longitudinal series; an inconspicuous series of actinal plates, a few of the proximals sporadically spiniferous; gonads opening ventrally; actinostome sunken, the adoral carina narrow and composed of four or five pairs of contiguous postoral adambulacral plates.

1. CALVASTERIAS ASTERINOIDES Perrier.

Calvasterias asterinoides Perrier, 1875, p. 84.

Falkland Islands; probably not Torres Strait, as specified by Perrier.

2. CALVASTERIAS ANTIPODUM Bell.

Calvasterias antipodum Bell, Proc. Zool. Soc., 1882, p. 122, pl. 6, fig. 1.

Mr. G. A. Smith of the British Museum (Natural History) has sent me a description of the type together with photographs of the skeleton. This species is a typical *Calvasterias* with thick skin and very large superomarginal plates. The carinal ridge carries a narrow zone of coarse tubercles (one or two wide) continued as a pentagon on the disk. No others are present. The superomarginals are very broad, with a large beaded area, and are wider than the dorsolateral area. Each inferomarginal carries two short, obtuse, granular spines which are set at an angle of 45° to the wall of the ray. On the dorsal side of their bases these spines have become engulfed in the thick integument.

3. CALVASTERIAS LAEVIGATA (Hutton).

Asterias rupicola var. *laevigata* Hutton, Trans. New Zeal. Inst., vol. 11, 1879, p. 353.

Stichaster suteri var. *laevigatus* Farquhar, Trans. New Zeal. Inst., vol. 30, 1897, p. 189; Proc. Linn. Soc. N. S. Wales, 1898, p. 313.—Benham, Subantarctic Islands of New Zealand. Echinoderms, 1909, p. 302.

Calvasterias laevigata Fisher, 1923, p. 606.—Mortensen, 1925, p. 311, pl. 13, fig. 12; pl. 14, figs. 3–10.

New Zealand: Auckland Islands; Campbell Island.

4. CALVASTERIAS SUTERI (de Loriol).

Stichaster suteri de Loriol, Rev. Suisse de Zool., vol. 2, 1894, p. 477, pl. 23.—Farquhar, Journ. Linn. Soc. Zool., vol. 26, p. 197; Proc. Linn. Soc. N. S. Wales, 1898, p. 313.—Benham, Subant. Islands of New Zealand. Echinoderms, 1909, p. 302.

Stichaster littoralis Farquhar, Trans. New Zeal. Inst., vol. 27, 1895, p. 206, pl. 13.

Stichorella suteri Koehler, 1920, pp. 87–89, pl. 22, figs. 1, 2, 4; pl. 62, fig. 3; pl. 63, fig. 1.

Calvasterias suteri Fisher, 1922, p. 597; 1923, p. 606.—Mortensen, 1925, p. 310.

New Zealand.

5. CALVASTERIAS STOLIDOTA Sladen.

Calvasterias stolidota Sladen, Challenger Asteroidea, 1889, p. 590, pl. 101, figs. 3, 4; pl. 103, figs. 11, 12.

Port William, Falkland Islands; Messier Channel, southern Chile.

Mr. G. A. Smith has sent me a description and photographs of the skeleton of this species which, from Sladen's figures, resembles a *Kalyptasterias.* The dorsolateral area is broader and the superomarginals much smaller than in typical *Calvasterias.* The abactinal skeleton is well developed with strongly overlapping carinals. The mostly 3-lobed dorsolaterals form an irregular open reticulum, in which three or four meshes can be counted between the carinals and superomarginals. The area is nearly or quite twice as wide as the superomarginal plates, and hence much broader than in *antipodum,* in which the superomarginals are wider than the dorsolateral area.

Genus COSMASTERIAS Sladen

Cosmasterias Sladen, subgenus, Challenger Asteroidea, 1889, p. 576. Type, *Asteracanthion sulcifer* Perrier = *A. luridum* Philippi.
Diplasterias Perrier, part, Mission sci. Cap Horn, 1891, p. 77.—Meissner, 1904, p. 6.
Comasterias Perrier, Mission sci. Cap Horn, 1891, p. 159.
Podasterias Perrier, Mission sci. Cap Horn, 1891, p. 160.
Quadraster Perrier, Rés. camp. Prince de Monaco, 1896, p. 27. Type, *Stichaster felipes* Sladen.

Diagnosis.—Actinal plates in two or more prominent longiseries forming the actinal or the actinal and actinolateral surfaces of ray (and not dominated or overhung by the inferomarginal plates); adambulacral plates diplacanthid, without attached pedicellariae; large unguiculate straight pedicellariae; plates of the abactinal area of ray have the appearance of forming definite longiseries, the carinals and superomarginals being conspicuously regular, and the dorsolateral area generally rather narrow with the plates in discernible longiseries; actinostome sunken, the adoral carina long, consisting of three or more contiguous pairs of adambulacral plates; gonads opening dorsally; not paedophoric.

Southern Hemisphere.

This genus is in need of thorough revision. It appears to be distantly allied to *Stichaster*. In the following provisional list of species I have not included *Asterias* (*Polyasterias*) *fernandensis* Meissner,[38] listed by Verrill (1914, p. 360) as *Cosmasterias fernandensis*. The genus is probably represented on Juan Fernandez,[39] but Meissner's species is almost certainly the young of *Astrostole platei* [40] from the same locality.

I have omitted also *Cosmasterias radiata* Koehler (1923, p. 36, pl. 2, fig. 5, pl. 3, figs. 1 and 2) dredged in 160 meters on Shag Rock Bank, between Falkland Islands and South Georgia. The specimens, almost certainly immature, have 8 to 10 equal or subequal rays, and a single madreporic plate. The species is fully described by Koehler who has placed it provisionally in *Cosmasterias*.

1. COSMASTERIAS LURIDA (Philippi).

Asteracanthion luridum Philippi, Arch. Naturges., vol. 24, 1858, p. 265.
Asteracanthion sulcifer Perrier, Ann. Sci. Nat., 1869, p. 235.
Asterias sulcifera Perrier, Rév. Stell., 1875, p. 58.
Asterias (*Cosmasterias*) *sulcifera* Sladen, Challenger Asteroidea, 1889, p. 562.—Leipoldt, Zeit. Wiss. Zool., vol. 59, 1895, p. 552 (literature list).
Comasterias sulcifera Perrier, Miss. Sci. Cap. Horn, 1891, p. 160.
Cosmasterias sulcifera Perrier, Expéd. Travailleur et Talisman, 1894, p. 107.
Cosmasterias lurida Ludwig, Expéd. Antarct. Belge, 1903, p. 40.—de Loriol, 1904, p. 39.—Koehler, 1912, p. 22, pl. 2, fig. 1–7; pl. 5, fig. 8; 1923, p. 39.

To this species Leipoldt, 1895, unites *Asteracanthion clavatum* Philippi, *A. fulvum* Philippi, *A. spectabile* Philippi, *A. mite* Philippi, and *Stichaster polygrammus* Sladen. (See below.)

Region of the Straits of Magellan and adjacent coasts on both Atlantic and Pacific sides; Tierra del Fuego; south Georgia; low tide to 348 fathoms.

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[38] Meissner, Arch. Naturges., 1896, p. 104, pl. 6, figs. 1, 1*a*–1*b*.

[39] Lieberkind, The Natural Hist. of Juan Fernandez. Edited Skottsberg, vol. 3, 1920, p. 388 (record of a young *Cosmasterias*).

[40] Meissner, 1896, p. 103, pl. 6, fig. 2, *Asterias* (*Coscinasterias*) *platei*. See also Lieberkind, 1920, p. 387.

2. COSMASTERIAS GERMAINI (Philippi).

Asteracanthion Germaini Philippi, Arch. Naturges, 1858, p. 265.—Koehler, 1912, p. 19.
Asterias (*Cosmasterias*) *tomidata* Sladen, Challenger Asteroidea, 1889, p. 576, pl. 105, figs. 8–10.
Diplasterias Germaini (Philippi), Meissner, Hamburger Magalhaen. Sammelr., 1904, p. 7.
Cosmasterias tomidata Verrill, 1914, p. 359.

Gulf of Peñas, Chile, 45 fathoms; region of the Straits of Magellan; off Argentina, latitude 44° 52′ S., 55 fathoms (Mus. Comp. Zoöl.).

3. COSMASTERIAS POLYGRAMMA (Sladen).

Stichaster polygrammus Sladen, 1889, p. 434, pls. 100, 103.
Cosmasterias polygrammus Verrill, 1914, p. 360.

West of Magellan Strait, 245 fathoms (Sladen).

4. COSMASTERIAS CAPENSIS (Perrier).

Asterias capensis Perrier, Rév. Stell., 1875, p. 73.
Stichaster felipes Sladen, 1889, p. 433, pl. 101, figs. 1 and 2; pl. 103, figs. 7 and 8.
Quadraster felipes Perrier, Rés. camp. Prince de Monaco, 1896, p. 27.
Cosmasterias felipes Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 10, 1923, p. 198.
Cosmasterias capensis Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 10, 1923, p. 198.

Cape of Good Hope, to 150 fathoms.

5. COSMASTERIAS DYSCRITA H. L. Clark.

Cosmasterias dyscrita Clark, Biol. Res. Fishing Exper. carried on by the F. I. S. *Endeavour*, 1909–1914, vol. 4, pt. 1, 1916, p. 71, pl. 29, figs. 1, 2.

South of Gabo Island, Victoria, 200 fathoms.

Genus CRYPTASTERIAS Verrill

Diplasterias Koehler, part, Expéd. antarct. Française, Échinodermes, 1906, p. 19; 1908, p. 574.
Cryptasterias Verrill, Shallow-water Starfishes, 1914, p. 362. Type, *Diplasterias turqueti* Koehler.—Koehler, 1920, p. 57; 1923, p. 25. Fisher, 1923, p. 604.

Diagnosis.—Related to *Diplasterias*, but abactinal surface soft, rather irregularly and finely papillose and the abactinal plates thin (with rudimentary spinelets only), forming an irregular reticulum entirely concealed by the skin; superomarginal plates well developed, bearing one spine wreathed with pedicellariae, and having long descending processes which support a broad, vertical, intermarginal channel; inferomarginals with two webbed spines (each with a cluster of pedicellariae on outer face) or with one spine; no actinal plates; adambulacral plates regularly diplacanthid; with two contiguous pairs of postoral adambulacral plates; interbrachial septum strongly calcified; gonads opening ventrally, eggs very large; good-sized, broadly lanceolate straight pedicellariae on furrow margin; rays five to eight.

Koehler, 1923, p. 25, includes two species, the type and *C. brachiata*. I am not certain of the status of *Diplasterias induta* Koehler (1908, p. 575) which is described as being close to *turqueti* and hence probably a *Cryptasterias*. But Koehler (1923, p. 27) states that other than *branchiata*, *turqueti* is the only known species.

1. CRYPTASTERIAS TURQUETI (Koehler).

Diplasterias turqueti Koehler, 1906, p. 19, pl 2, fig. 17; pl. 4, fig. 39.
Cryptasterias turqueti Verrill, 1914, p. 362.—Koehler, 1920, p. 57, pl. 17, figs. 1–5.

Booth Wandel Island; South Orkney Islands; 9 to 20 fathoms.

2. CRYPTASTERIAS BRACHIATA Koehler.

Cryptasterias brachiata Koehler, 1923, p. 25, pl. 1, figs. 9, 10.

Berkeley Sound, Falkland Islands, 25 to 30 meters.

Genus DIPLASTERIAS Perrier

Diplasterias Perrier, Comptes-rendus, vol. 106, no. 11, 1888, p. 765; Mission sci. Cap Horn, Échinodermes, 1891, p. 77. Type, *Diplasterias lütkeni* Perrier.—Fisher, Smithsonian Miscell. Coll., vol. 52, 1908, p. 89. (Error in assignment of *sulcifera* as type.)

Podasterias Perrier, Expéd. sci. Travailleur et Talisman, 1894, pp. 107, 108; Camp. sci. du Prince de Monaco, 1896, p. 35. Type, *Diplasterias lütkeni* Perrier (not *Podasterias* Perrier 1891, p. 160).—Fisher, Ann. and Mag. Nat. Hist., ser. 9, vol. 12, 1923, p. 603; Zool. Anz., vol. 33, 1908, p. 358.

Diagnosis.—Adambulacral plates diplcanathid, without attached pedicellariae; abactinal skeleton irregularly reticulate; the plates with one to several slender spines surrounded by a collar of pedicellariae and more or less heavily sheathed with membrane which usually obscures skeleton; marginal plates well developed; superomarginal spines one or two, conspicuous, clearly differentiated from abactinal and surrounded by pedicellariae; inferomarginal spines usually two, sporadically three, bearing pedicellariae and forming definite longitudinal series separated from superomarginals by a well-defined intermarginal channel; actinal spines with attached pedicellariae, in one or two longiseries (actinals exceptionally spineless); two to four pairs of contiguous postoral adambulacral plates; not fissiparous; gonads opening ventrally; young brooded by adult; straight pedicellariae lanceolate, typically not enlarged nor unguiculate. Differing from *Anasterias* in having a stronger abactinal skeleton and diplacanthid adambulacral plates.

Remarks.—In the first reference to *Diplasterias* (1888) Perrier cites *D. lütkeni* Perrier and *D. steineni* Studer as species which brood their young. He adds: "Je classe dans le genre *Diplasterias* les *Asterias* qui ont deux rangées au moins de piquants adambulacraires."

In the Cape Horn report, published three years later, *Diplasterias* is entered as a new genus, with the same diagnosis. Five species are enumerated and described: *D. sulcifera* (Perrier, 1869), *D. loveni* Perrier, *D. lütkeni* Perrier, *D. spinosa* Perrier, *D. steineni* (Studer).

Diplasterias was thus formally published in connection with definite species from which a type may be selected. If the first reference is to be regarded as a nomen nudem, as I suggested in 1908 (Fisher, 1908*a*, p. 89) the enumeration of *D. lütkeni* and *D. steineni* (both of which are *Diplasterias* in the narrowest sense) is useful as an indication of the species which Perrier had in mind for his new, if somewhat indefinite, genus. While Perrier's Cape Horn report was in press, Sladen used Perrier's first species, *D. sulcifera*, for the type of *Cosmasterias*. My choice, in 1908, of *D. sulcifera* as the type of *Diplasterias* was ill advised, due to a strict adherence to the "first species rule" for the determination of a type when none is indicated by the author. It seems to me that the oldest known species, *Asterias brandti* Bell, which includes both *Diplasterias lütkeni* and *loveni* (cited by Perrier in 1891) should be chosen, especially as *D. lütkeni* appears in the first, or Comptes-rendus, citation.

Diplasterias obviously antedates *Podasterias*, Perrier 1894, even if the generic diagnosis is vague in the light of modern information. *Diplasterias* made no deep impression on Perrier's mind, because he readily abandons it on page 160 of the Cape Horn paper, in a comment on Sladen's recently published subdivisions of *Asterias*. Here he merges his *Diplasterias* with Sladen's *Asterias*.

On the same page (1891, p. 160) he unfortunately introduces *Podasterias* for the *Asterias sulcifera* group, stating that *Cosmasterias* has priority for this generic division. This is the first occurrence of *Podasterias* in literature. But in 1894,[41] disregarding his *Podasterias* of 1891, he introduced a quite different *Podasterias* for species near *A. lütkeni*. This is precisely synonymous with his *Diplasterias* of 1891, and is the *Podasterias* used by Verrill, Koehler after 1917, and Fisher, 1923. *Podasterias* of 1891 must obviously be discarded for *Cosmasterias*, while that of 1894 had no status when proposed, being a homonym of the first, as well as a synonym of *Diplasterias*.

Disregarding his *Diplasterias* of 1891, Perrier in 1894 [41] employs *Diplasterias* in a different sense, namely for *Asterias* Linnaeus. In this paper the Asteriidae lack a genus *Asterias*.

In 1896 [42] *Podasterias* is preserved for *Diplasterias lütkeni*, *Asterias* is reinstated, and *Diplasterias* discarded entirely.

Ludwig in 1903 [43] used *Diplasterias* in the sense in which I advocate employing it. Meissner in 1904 [44] employed the name for *Cosmasterias* plus *Diplasterias*. Koehler in 1906, 1908, and 1912, used *Diplasterias* to include *Cryptasterias* Verrill, 1914. In 1917 and subsequent papers Koehler adopted *Podasterias* with the limits I have assigned to *Diplasterias*. In 1914 Verrill [45] used *Podasterias* for *Diplasterias* but erroneously assigned *Asterias brandti* Bell, *A. alba* Bell, *A. neglecta* Bell, and *A. obtusispinosa* Bell to *Cosmasterias*, the last three as possible synonyms of *C. lurida* (Philippi).

Dr. R. Koehler has contributed two species to this genus and valuable notes and figures of others in his beautifully illustrated reports on Antarctic sea stars [46] wherein the evolution of our knowledge of the group may be traced.

Subgenus DIPLASTERIAS ss.

Diagnosis.—Actinal plates in one or two longiseries; actinal spines in one or two longiseries, armed with clusters of pedicellariae; adoral carina composed of from one to three pairs of contiguous adambulacrals.

1. DIPLASTERIAS BRANDTI (Bell).

Asterias brandti Bell,Proc. Zool. Soc., 1881, p. 91, pl. 9.
Asterias neglecta Bell, Proc. Zool. Soc.,1881, p. 94. pl. 9.
Asterias alba Bell, Proc. Zool. Soc., 1881, pp. 92, 506.
Asterias obtusispinosa Bell, Proc. Zool. Soc., 1881, pp. 92, 93.
Asterias belli Studer, Abh. Akad. Berlin, 1884, pp. 12, 13, pl. 1.
Asterias glomerata Sladen, Challenger Asteroidea, 1889, p. 571, pl. 105.
Diplasterias loveni Perrier, Miss. sci. Cap Horn ,1891, p. 80.
Diplasterias lütkeni Perrier, Miss. sci. Cap Horn, 1891, p. 81.—Ludwig, 1903, p. 41.

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[41] Expéd. Travailleur et Talisman, pp. 107, 108 (key).

[42] Résultats camp. sci. Prince de Monaco, fasc. 11, 1896, pp. 34, 35.

[43] Expédition Anarctique Belge, Seesterne, p. 41.

[44] Hamburger Magalhaensische Sammelreise, Asteroideen, pp. 5–9.

[45] Shallow-water Starfishes, p. 361.

[46] See Koehler, 1908, p. 572 (*Diplasterias*); 1912, pp. 12 et seq. (*Diplasterias*); 1917, pp. 20–29 (*Podasterias*); 1920, pp. 35–51 (*Podasterias*); 1923, pp. 27–35 (*Podasterias*).

Diplasterias brandti MEISSNER, 1904, p. 7.—KOEHLER, 1908, p. 572, pl. 5, figs, 50, 51; 1912, p. 19, pl. 1, figs. 3, 5, 6.
Podasterias brandti KOEHLER, 1917, p. 26, pl. 4, figs. 16, 17; pl. 5, figs. 11, 13, 14; 1920, pp. 41, 51, pl. 13, fig. 11; pl. 16, figs. 5, 6; 1923 p. 27, pl. 2, figs. 2, 3.

Koehler points out that *D. brandti* is a polymorphic species. This is certainly the case if *glomerata*, *alba*, and *obtusispinosa*, the types of which I have examined, are to be ranked as one species. *Alba* and *obtusispinosa* are formae of the same species, but they are wholly unlike *glomerata*. Bell's *neglecta*, a fine specimen of which is in the British Museum (1901–5–10–65, Southern Cross expedition) appears to be a fully grown example of forma *glomerata* (R 160 mm., r 24 or 25 mm.), *neglecta* having priority.

It is likely that a number of well-marked formae will eventually be recognized. Koehler has already given *glomerata* varietal rank (1923, p. 29).

South Georgia; Falkland Islands; region of the Straits of Magellan, north to latitude 44° 14′ S., and longitude 53° 43′ W.

2. DIPLASTERIAS BRUCEI (Koehler).

Stolasterias brucei KOEHLER, 1908, p. 569, pl. 5, figs. 46, 47.
Coscinasterias brucei KOEHLER, 1911, p. 30, pl. 5, fig. 5.
Coscinasterias victoriae KOEHLER, 1911, p. 32, pl. 5, figs. 3, 4; 1912, p. 24.
Podasterias brucei KOEHLER, 1920, p. 42, pl. 11, figs. 5–7; pl. 13, figs. 1–9; pl. 14, figs. 4, 7–11; pl. 15, figs. 4, 5; 1923, p. 35, p. 13, fig. 2.—DÖDERLEIN, 1928, p. 295.

South Orkneys; Graham Land; Adelie Land to longitude 92°.

3. DIPLASTERIAS FOCHI (Koehler).

Podasterias fochi KOEHLER, 1920, p. 35, pl. 14, figs. 1, 2, 12; pl. 15, figs. 1, 2, 3,; pl. 16, figs. 2, 3, 7; pl. 58, fig. 1.

Antarctic from east longitude 92° to 141°; Adelie Land.

4. DIPLASTERIAS KERGUELENSIS (Koehler).

Podasterias kerguelensis KOEHLER, 1917, p. 24, pl. 4, figs. 3, 4, 12, 13, 19.

Kerguelen.

5. DIPLASTERIAS MERIDIONALIS (Perrier).

Asterias meridionalis PERRIER, Rév. des Stell., 1875, p. 76.
Asterias mollis STUDER, Abh. Akad. Wis., Berlin, 1884, p. 8.
Asterias studeri BELL, Proc. Zool. Soc., 1881, p. 91.—STUDER, Abh, Akad. Wiss., Berlin, 1884, p. 8, pl. 1, fig. 1.
Podasterias meridionalis KOEHLER, 1917, p. 20, pl. 2, figs. 11, 12; pl. 3, figs. 1, 2, 4, 5, 6, 7; pl. 6, fig. 8; pl. 7, fig. 9; 1923, p. 31, pl. 2, fig. 1; pl. 13, fig. 1.—DÖDERLEIN, 1928, p. 294.

South Georgia; Kerguelen.

Subgenus BATHYASTERIAS, new

Diagnosis.—One series of *spineless* actinal plates. Abactinal skeleton weak, irregularly reticulate, with small meshes; body overlaid by soft, puffy, wrinkled skin which involves base of spines; rather wide intermarginal channel; superomarginal plates monacanthid with long descending process which strongly overlaps the rather long ascending lobe of the diplacanthid inferomarginals; conspicuous series of intermarginal and actinal papulae in addition to abactinal; actinostome small; adoral carina narrow, comprising four pairs of postoral adambulacral plates. Type, *Asterias vesiculosa* Sladen.

6. DIPLASTERIAS VESICULOSA (Sladen).

Asterias vesiculosa Sladen, Challenger Asteroidea, 1889, p. 568, pl. 99, figs. 1, 2, pl. 103, figs. 1, 2.

Arafura Sea (lat. 5° 41′ S., long. 134° 4′ 30″ E.), 800 fathoms.

I examined the type in the British Museum. This species seems clearly related to *Diplasterias* ss., but lacks actinal spines and has a longer, narrower, adoral carina.

Genus EREMASTERIAS, new

Diagnosis.—Resembling *Smilasterias* Sladen in having a small-meshed, reticulate, abactinal skeleton beset with small irregularly disposed spinelets and a chevaux-de-frise along the actinolateral border of ray consisting of consecutive transverse combs of three or four, much larger, flattened, spatulate inferomarginal and actinal spines, devoid of attached pedicellariae. Differing in having monacanthid adambulacral plates and a more pronounced adoral carina consisting of several pairs of adambulacral plates. Crossed pedicellariae scattered, rare, resembling those of *Sporasterias*; a few incipiently unguiculate straight pedicellariae. One series of spiniferous actinal plates. Type, *Pisaster antarcticus* Koehler.

Remarks.—The above diagnosis does not agree with Koehler's excellent description in one important point. The position of the combs of actinolateral, spatulate spines, distributed on two longiseries of plates, suggests that these plates are respectively inferomarginal and actinal, as in *Smilasterias*, which *Eremasterias* strongly resembles. Doctor Koehler identifies as marginals two longiseries, bearing small spinelets, above these combs. I think it likely that Koehler's superomarignal plates are in reality a regular series of dorsolateral (abactinal) plates, while his inferomarginals are *superomarginals.* Doctor Koehler states (p. 32) that the number of spines to each comb does not diminish toward the end of ray. This is not normal behavior for *actinal* spines and points rather to the interpretation I have given above, namely that the spines are borne on the inferomarginal and one series of actinals as in *Smilasterias scalprifera.* If Doctor Koehler's interpretation is the correct one, then the difference between *Eremasterias* and *Smilasterias* is even greater than indicated in the diagnosis; for there is no doubt that the main part of the fan of spines in *Smilasterias* is carried on the inferomarginals. In *S. triremis* actinal plates are lacking.

This genus is not closely related to *Pisaster*, which has highly characteristic, tiny, straight pedicellariae, with bifid falcate jaws, not found eleswhere among Asteroidea.

1. EREMASTERIAS ANTARCTICA (Koehler).

Pisaster antarcticus Koehler, Ann. l'inst. océanographique, vol. 7, fasc. 8, 1917, p. 30, pl. 9, figs. 5, 6, 7, 8, 10, 17.

Kerguelen, littoral.

Genus GRANASTER Perrier

Granaster Perrier, Expéd. sci. Travailleur et Talisman, 1894, pp. 129, 133. Type, *Stichaster nutrix* Studer.—Fisher, 1923, p. 604 (including *Hemiasterias*).

Hemiasterias Verrill, Shallow-water Starfishes, 1914, p. 362, footnote. Type, *Granaster biseriatus* Koehler.

Diagnosis.—Small, paedophoric sea stars with short robust rays, diplacanthid and triplacanthid adambulacrals, and the whole body covered with a rather uniform coarse granulation of short, capitate spinelets, without serial arrangement, interspersed with scattered pedicellariae; skeleton, not externally visible, consists of three to five lobed plates, directly imbricated by their lobes, leaving skeletal intervals smaller than plates; marginal plates four lobed, obscured by granules; an incomplete series of actinals; papulae mostly solitary; interbrachial septum incomplete—simply a calcified pillar passing obliquely upward from the odontophore to the dorsal wall, leaving a large, free passage, adjacent to margin, from one ray to next; gonads large, opening ventrally; adoral carina very short, composed of one pair of plates; tube feet in two, three, or four series; straight pedicellariae ovoid or triangular, often nearly as large as spinelets; crossed pedicellariae, few, relatively large, scattered among the spinelets.

This genus is very distinct and of uncertain relationship. The general facies is unlike that of any other asteriid, the dorsal aspect suggesting a little *Cycethra* or *Perknaster*. Only one species is known.

GRANASTER NUTRIX (Studer).

Stichaster nutrix STUDER, Jahrb. wiss. Anst. Hamburg, vol. 2, 1885, p. 1554, pl. 5*a*.
Granaster nutrix PERRIER, 1894, p. 129.—KOEHLER, 1923, p. 53.
Granaster biseriatus KOEHLER, 1906, p. 11, pl. 1, fig. 6; pl. 4, fig. 42; 1908, p. 565, pl. 5, figs. 48, 49; 1912, p. 29, pl. 3, fig. 2; pl. 6, fig. 1.
Hemiasterias biseriata VERRILL, 1914, p. 362.

South Georgia; South Orkneys; Graham Land; low tide to 250 meters.

I have examined two specimens from Wandel Island, Graham Land, West Antarctica.

Genus KALYPTASTERIAS Koehler

Kalyptasterias KOEHLER, Swedish Ant. Exped., vol. 1, no. 1, 1923, p. 43. Type, *K. conferta* Koehler.

Diagnosis.—Differing from *Anasterias* Perrier (which it resembles in having monacanthid adambulacrals and a weak, irregularly reticulate, abactinal skeleton overlaid by a thick, soft skin) in the weaker development of the superomarginal plates, which form a rather irregular series and bear, sporadically, a single spinelet. Whole body covered by a thick soft integument concealing the contour of the plates; abactinal surface very convex, the two marginal series at the ventral border of ray; abactinal surface with four or five irregular longiseries of numerous large papulae, on either side of carinal line, alternating with longitudinal zones of bare skin, slightly wrinkled; superomarginal plates rather small, irregular, inconstant in form, constituting a series very irregular and sinuous on some rays and more rectilinear on others; inferomarginals normally developed, diplacanthid; one series of small, usually spiniferous, actinals. Abactinal spinelets small, fairly numerous to scarce; crossed pedicellariae scarce, not in circles around spinelets; straight pedicellariae lanceolate.

This group is very close to true *Anasterias.* The latter has both series of marginals well developed and normal, but with increasing age the superomarginals may lose their spine. See under *Anasterias,* Remarks.

There seems to be no question that this genus is perfectly distinct from *Calvasterias.* It will not be surprising however if it intergrades perfectly with *Anasterias.*

1. KALYPTASTERIAS CONFERTA Koehler.

Kalyptasterias conferta Koehler, 1923, p. 43, pl. 4, figs. 4–7.

Falkland Islands (Port Louis, 4 to 7 meters).

Genus KOEHLERASTER Fisher

Koehleraster Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 10, Dec. 1922, p. 596. Type, *Anasterias octoradiata* Koehler.

Diagnosis.—Differs from *Lysasterias* in having an open but perfectly normal, irregularly reticulate, abactinal skeleton and well developed marginal skeleton; differs from *Anasterias* and *Sporasterias* in possessing a thick, highly pustulated, "cauliflower" skin. Adambulacral plates monacanthid, but a few proximally occasionally diplacanthid; a very inconspicuous series of small spineless actinal plates; abactinal skeleton an irregular but complete reticulum of small, imbricated mostly simple elliptical or oblong, occasionally faintly lobed plates; carinal series very irregular; superomarginals monacanthid, inferomarginals mostly diplacanthid, the spines surrounded by mammillated sheaths which contain (like those of dorsal surface) a few fair-sized crossed pedicellariae without enlarged terminal teeth; numerous scattered, narrowly spatulate to compressed, broadly lanceolate, often pedunculate straight pedicellariae; tube feet crowded, large, quadriserial; gonads open ventrally, although attached on level with marginal plates; adoral carina composed of four pairs of contiguous adambulacral plates; numerous (eight or nine) rays.

KOEHLERASTER OCTORADIATUS (Koehler).

Anasterias octoradiata Koehler, Science Bull. Mus. Brooklyn Inst. Arts and Sciences, vol. 2, no. 4, 1914, p. 64, pl. 14, figs. 1–7. South Georgia. Also 1923, p. 14, pl. 6, fig. 6.

South Georgia, 10 to 15 meters.

I have examined the type which is now in the United States National Museum. This is eight rayed, while the second specimen (Koehler, 1923) is nine rayed.

The species is evidently allied to true *Anasterias*. It has a *complete* irregularly reticulate abactinal skeleton consisting of very numerous, small, but fairly robust, oval, elliptical-oblong, and a few irregularly 3-lobed plates (the latter perhaps representing primary dorsolaterals). There is an irregular carinal series, of which the plates are no larger than the others. The abactinal plates are joined to the superomarginals by transverse bands of plates which are a little more regular than the others, and between consecutive trabeculae are broad (but short) papular areas, which form a zone just above the superomarginal plates. These papular areas, or skeletal meshes, are larger than the other abactinal and the intermarginal meshes.

The marginal plates are fairly robust and of the form usually found in the Asteriinae—namely, four lobed. The descending lobe of the superomarginal is the longest, and strongly overlaps the ascending lobe of the inferomarginal. The superomarginals are regularly monacanthid, while most of the inferomarginals are diplacanthid. There is a very inconspicuous series of small spineless actinal plates.

The gonads are not present in all rays, and are attached to the body wall on a level with the superomarginals; but the duct turns downward, and I believe that I have demonstrated its external opening on the ventral surface, on a papilla, close to the interradial line.

The thick dermis is raised into conspicuous cauliflowerlike pustules which inclose spinelets and entirely obscure the skeleton.

The genus is named in honor of Dr. Réné Koehler, of Lyons, the leading authority on Antarctic echinoderms.

Genus LYSASTERIAS Fisher

Lysasterias Fisher, Smithsonian Miscell. Coll., vol. 52, May, 1908, p. 88; Zool. Anz., vol. 33, Aug. 1908, p. 356. Type, *Anasterias perrieri* Studer, 1885, but not Perrier 1891.—Fisher, 1922, p. 594; 1923, p. 606; 1926, p. 197.

Anasterias Ludwig, 1903, p. 42.—Koehler, 1906, p. 12; 1908, p. 566; 1912, p. 10; 1920, p. 11; 1923, p. 11.—Verrill, 1914, p. 354.—Not *Anasterias* Perrier, 1875; not *Asteroderma* Perrier, 1875.

Paedasterias Verrill, Shallow-water Starfishes, 1914, p. 355. Type, *Anasterias chirophora* Ludwig.—Koehler, 1920, pp. 16, 30.

Diagnosis.—Marginal and abactinal skeleton much reduced, consisting of lateral, spaced, transverse series or tongues of plates (composed of two reduced marginals plus sometimes one or several abactinals) abutting on the adambulacral plates; dorsal surface with much reduced, disconnected, scattered platelets; dermis thick, surrounding the spinelets in mammillated pustules; adambulacral plates monacanthid; no actinal spines, the plates if present extremely rudimentary; gonads open ventrally—paedophoric.

This genus has usually been incorrectly called *Anasterias* (q. v.).

Verrill's genus *Paedasterias* was founded pretty largely upon an erroneous translation. Ludwig (1903, p. 42), in a synopsis of "*Anasterias*" says: "Die Spagen haben (mit Ausnahme der Armspitze) *keinen oberen Randstachel;* grosse Tatzenpedicellarien vorhanden * * * *An. chirophora* n. sp." Verrill diagnoses the genus: "* * * *the upper marginal plates* being absent except as rudiments distally." But Ludwig in a major division of his synopsis states that the upper marginal plates are present in *chirophora.* Koehler (1920, p. 30) has adopted *Paedasterias,* and added a new species, *joffrei.*

Koehler finds in his *Paedasterias joffrei* abactinal cross-bars of several pieces, as in *Lysasterias belgicae* (Ludwig); but he thinks that the superomarginals are not to be found in these arcs. Rather, they are one or two plates in the interbrachial angle above the first inferomarginals, and quite independent of the little cross-tiers of the rays, where the superomarginal would consequently be lacking. In a specimen of *Anasterias tenera* which I have examined (No. 1842, Mus. Comp. Zoöl.) these "antiambulacral" arcs consist usually of two, sometimes three, plates; but the outer *usually spiniferous* superomarginal is oriented transversely and the inner, or inferomarginal, more longitudinally just as in *chirophora, lactea,* and *perrieri.* Koehler may be correct in his interpretation of the lateral plates of *joffrei* and *belgicae.* But I think that the outer of the two plates in the antiambulacral arcs of *chirophora, lactea,* and *perrieri* is to be interpreted as *superomarginal.* The type of *Paedasterias* equally with that of *Lysasterias* would possess superomarginals. The presence in *belgicae* and *studeri* of several plates (instead of two) in each lateral arc probably represents simply a less degenerate condition of the abactinal skeleton. In *tenera* one or two small plates are sporadically present above the relatively large, unmistakable, transversely oriented, superomarginal. These small plates are homologous with the additional lateral plates of *belgicae.* It follows, therefore, that there is nothing characteristic about the marginal plates of *chirophora*, which are identical with those of the type of *Lysasterias*. If *Paedasterias* is maintained as a genus, it must be on the strength of the large spatulate unguiculate, straight pedicellariae. But in *P. joffrei* these are less developed than in *chirophora*, while the lateral arcs are not those of *chirophora* but of *belgicae*, in Ludwig's *second* group. If the pedicellariae are used as a criterion for separation, then the structure of the skeleton must be disregarded.

1. LYSASTERIAS ADELIAE (Koehler).

Anasterias adeliae KOEHLER, 1920, pp. 16, 26, pl. 1, figs. 1, 2, 5–10, pl. 56, fig. 1.

Adelie Land, 12 fathoms.

2. LYSASTERIAS BELGICAE (Ludwig).

Anasterias belgicae LUDWIG, 1903, p. 51, pl. 6, figs. 61–65; pl. 7, figs. 66–67.—KOEHLER, 1920, p. 17.

Latitude 70° 15′ S.; longitude 84° 06′ W.; 560 meters.

3. LYSASTERIAS CHIROPHORA (Ludwig).

Anasterias chirophora LUDWIG, 1903, p. 43, pl. 5, figs. 52–54; pl. 6, figs. 55–60; pl. 7, fig. 78.
Paedasterias chirophora VERRILL, 1914, p 371.—KOEHLER 1920, p. 16.

From latitude 70° 23′ to 71° 19′ S. and longitude 82° to 87° W., 450 meters.

4. LYSASTERIAS CUPULIFERA (Koehler).

Anasterias cupulifera KOEHLER, 1908, p. 566, pl. 5, fig. 52, pl. 6, figs. 58, 59; 1920, p. 16.

South Orkneys, 10 fathoms.

5. LYSASTERIAS JOFFREI (Koehler).

Paedasterias joffrei KOEHLER, 1920, p. 30, pl. 1, figs. 3, 4, 9; pl. 2, figs. 7, 8, 9; pl. 56, fig. 2.

Latitude 66° 50′ S.; longitude 142° 06′ E.; 354 fathoms.

6. LYSASTERIAS LACTEA (Ludwig).

Anasterias lactea LUDWIG, 1903, p. 50.—KOEHLER, 1920, p. 17.

Latitude 71° 09′ S.; longitude 89° 15′ W.; 450 meters.

7. LYSASTERIAS PERRIERI (Studer).

Anasterias perrieri STUDER, Die Seesterne Süd-Georgieus, Jahrb. wiss. Anst. Hamburg, vol. 2, 1885, p. 153.—KOEHLER, 1920, p. 17.
Anasterias lysasteria VERRILL, 1914, p. 354 (unnecessary substitute name; see Fisher, 1922, p. 593).

South Georgia.

8. LYSASTERIAS STUDERI (Perrier).

Anasterias studeri PERRIER, Miss. sci. Cap Horn, 1891, p. 99.—KOEHLER, 1920, p. 17.

Near Atlantic entrance to Magellan Strait, 320 meters.

9. LYSASTERIAS TENERA (Koehler).

Anasterias tenera KOEHLER, 1906, p. 12; pl. 2, figs. 11–16; pl. 3, figs. 27, 28; pl. 4, fig. 41; 1908, p. 569; 1912, p. 10; 1920, p. 11, 17.

South Shetland Islands; Graham Land; South Orkneys, Cumberland Bay, South Georgia; 1 to 420 meters.

10. LYSASTERIAS VICTORIAE (Koehler).

Anasterias victoriae KOEHLER, 1920, p. 17, pl. 2, fig. 5; pl. 3, figs. 1–6; pl. 4, figs. 1–4; pl. 5, figs. 1–10; pl. 6, figs. 1–4; pl. 57, fig. 1.

From latitude 64° to 67° S., and from longtitude 92° to 145° E., 60 to 354 fathoms. This species is possibly a true *Anasterias*.

Genus NEOSMILASTER, new

Diagnosis.—Resembling *Diplasterias* in having diplacanthid adambulacral plates, and gonads which open ventrally, but differing in having abactinal pedicellariae scattered among the spinelets rather than in circlets on the circumspinal sheaths; in lacking a definite, well-marked series of enlarged superomarginal spines; in having the inferomarginal spines in oblique, transverse combs of three or four (as in *Smilasterias*) but with a few attached pedicellariae; one series of actinal spinelets close to adambulacrals; an intermarginal series of prominent lanceolate pedicellariae; abactinal skeleton an irregular, close, or medium open net, the small spinelets, with interspersed papulae, either close-set or spaced, according to the relative compactness of skeleton; superomarginal spinelets similar to abactinal. Type, *Asterias georgiana* Studer.

The species of this group resemble *Smilasterias*, but differ in having ventrally opening gonads.

1. NEOSMILASTER GEORGIANUS (Studer).

Asterias georgiana STUDER, Die Seesterne Süd-Georgiens, Jahrb. wiss. Anst. Hamburg, vol. 2, 1885, p. 150.
Diplasterias georgiana PERRIER, 1891, p. 7.
Podasterias georgiana KOEHLER, 1917, p. 26; 1920, p. 41.
Ctenasterias georgiana KOEHLER, 1923, p. 40, pl. 3, figs. 3–7, 10.

I have examined at the British Museum one of the original types purchased from the Hamburg Museum. Koehler has published (1923) good photographs. In my opinion *georgianus* is not closely related to *Leptasterias* (with which Verrill's *Ctenasterias* is synonymous), although there is undoubtedly a superficial resemblance, which exists also between some species of *Sporasterias* and *Leptasterias*.

The species has been taken at South Georgia, low tide to 75 meters; and Shag Rock Bank, between Falkland Islands and South Georgia, 160 meters.

2. NEOSMILASTER STEINENI (Studer).

Asterias steineni STUDER, Die Seesterne Süd-Georgiens, Jahrb. wiss. Anst. Hamburg, vol. 2 1885, p. 152, pl. 1, fig. 4*a*, *b*.
Diplasterias steineni PERRIER, 1891, p. 84.—KOEHLER, 1912, p. 20, pl. 1, figs. 4, 7, 10.
Podasterias steineni KOEHLER, 1917, p. 26; 1920, p. 41; 1923, p. 30, pl. 3, figs. 8, 9.

Tierra del Fuego; Falkland Islands; south of Cape Horn; 99 meters.

This species is clearly not congeneric with *Diplasterias brandti* and *brucei*. The small abactinal spinelets with scattered pedicellariae not in circlets; the absence of a conspicuous single or double series of superomarginal spines, either larger or plainly distinct from the abactinals; the inconspicuous intermarginal area or furrow; the crowded inferomarginal transverse combs of three or four spinelets—all segregate this species from typical *Diplasterias* and ally it to *georgianus*.

Genus PERISSASTERIAS Clark

Plate 71, Figure 3

Perissasterias H. L. Clark, The Echinoderm Fauna of South Africa, Annals of the South African Museum, vol. 8, pt. 7, May 1923, p. 307. Type, *P. polyacantha* Clark.—Fisher, 1926, p. 199.

Diagnosis.—Adambulacral plates short, with numerous (usually four or five but as few as two or three and as many as six or seven) spines, in transverse series, bearing small lanceolate straight pedicellariae; actinal area extensive with three to six longiseries of well-developed, 4-lobed spiniferous plates separated by regular longiseries of papular areas; abactinal plates cruciform, connected in transverse direction by oblong secondary ossicles, leaving medium-sized intervals; dorsolateral skeleton on either side of the evident carinal series, broad, rather irregular; but sometimes poorly defined longiseries of plates are evident; spines subacicular but strong, surrounded by a wreath of pedicellariae; carinals with one to six spines; dorsolaterals with usually one, marginals with two or three, and actinals with one to five spines; actinostome small, but not sunken, two or three pairs of postoral adambulacrals being in contact (pl. 71, fig. 3); papulae numerous; pedicellariae small, without outstanding characters; the straight are small, lanceolate; the crossed, similar to those of *Asterias* ss.; gonads open dorsally; size large; rays five to seven.

An isolated genus more nearly related to *Asterias* than to any group confined to Southern Hemisphere.

1. PERISSASTERIAS POLYACANTHA Clark.

Perissasterias polyacantha Clark, 1923, p. 307, pl. 18, fig. 3; 1926, p. 29, pl. 6.—Fisher 1926, p. 199.

Cape Colony: Off Cape Town, 156 fathoms; off Dassen Island, 170 fathoms.

2. PERISSASTERIAS HEPTACTIS Clark.

Perissasterias heptactis Clark, 1926, p. 26, pl. 5.

West from Lambert's Bay, Cape Colony, 210 fathoms.

3. PERISSASTERIAS OBTUSISPINA Clark.

Perissasterias obtusispina Clark, 1926, p. 28, pl. 7, figs, 1, 2.

Off Dassen Island, Cape Colony, 214 fathoms.

Genus SALIASTERIAS Koehler

Saliasterias Koehler, Austral. Ant. Exped., vol. 8, pt. 1, 1920, p. 52. Type, *S. brachiata* Koehler.—Fisher, 1923, p. 603.

Diagnosis.—Rays 9 or 10; skeleton irregularly reticulate; plates unequal and without indication of carinal or dorsolateral longiseries; on sides of rays transverse arcs of plates, of which the lowest is the inferomarginal, correspond to two narrow adambulacral plates and alternate with conspicuous, quadrangular membranous spaces (two adambulacrals in length), containing three or four papulae; no actinals; abactinal spinelets slender, cylindrical, in small groups, surround the membranous skeletal intervals containing three or four papulae; inferomarginal spines two or three identical with dorsals; adambulacrals with two long, slender, cylindrical, terminally rounded or truncate spinelets; crossed pedicellariae, upward of 0.4 mm. long and without enlarged terminal teeth, are scattered among the spinelets, rather abundantly on rays; straight pedicellariae, lanceolate, upward of 0.7 mm. long, less numerous.

1. SALIASTERIAS BRACHIATA Koehler.

Saliasterias brachiata Koehler, 1920, p. 54, pl. 11, figs. 1–4; pl. 12, figs. 1–8; pl. 58, fig. 3.—Fisher, 1923, p. 603.

Adelie Land, 15 to 20 fathoms; latitude 66° 50′ S.; longitude 142° 06′ E., 354 fathoms.

Genus SMILASTERIAS Sladen

Smilasterias Sladen (subgenus), Challenger Asteroidea, 1889, p. 562, 578. Type, *Asterias scalprifera* Sladen.

Diagnosis.—Small, 5-rayed forms with compact, reticulate abactinal and lateral skeleton beset with small spinelets; inferomarginals on ventrolateral border of ray, each with a prominent, oblique comb of three or four flattened truncate spines which radiate apart and are without attached pedicellariae; adambulacral plates with two or three slender spinelets, devoid of attached pedicellariae; a series of small spiniferous actinals in one species (*scalprifera*); adoral carina comprises first pair of postoral adambulacrals which are longer than second pair; crossed pedicellariae scattered, not in circlets around spinelets; straight pedicellariae lanceolate, scattered on all surfaces; in addition, sometimes, large spatulate unguiculate pedicellariae with curved, interlocking tines; tube feet in four series; one madreporic body; gonads open *dorsally* at upper margin of superomarginal plates, near interradius.

1. SMILASTERIAS SCALPRIFERA Sladen.

Asterias (*Smilasterias*) *scalprifera* Sladen, Challenger Asteroidea, 1889, p. 578, pl. 100, figs. 4–6; pl. 103, figs. 1 and 2.

Off Marion and Heard Islands, 50 to 75 fathoms.

2. SMILASTERIAS TRIREMIS Sladen.

Asterias (*Smilasterias*) *triremis* Sladen, Challenger Asteroidea, 1889, p. 578, pl. 101, figs. 5 and 6; pl. 102, figs. 5 and 6.

Between Kerguelen and Heard Islands, 150 fathoms.

3. SMILASTERIAS IRREGULARIS Clark.

Smilasterias irregularis Clark, Rec. South Austral. Mus., vol. 3, No. 4, 1928, p. 402, fig. 116.

South Australia: Spencer or St. Vincent Gulf.

This species has only two inferomarginal, flat, square-cut spines; no actinal plates; adambulacrals diplacanthid.

Note.—*Asterias* (*Smilasterias*) *terwieli* Goldschmidt (Ann. Mag. Nat. Hist., ser. 9, vol. 14, 1924, p. 499) from off the coast of Chile not only is not a *Smilasterias*, but does not even belong to the Forcipulata.

Genus SPORASTERIAS Perrier

Sporasterias Perrier, Expéd sci. Travailleur et Talisman, 1894, p. 107. Type, *Asterias rugispina* Stimpson.—Ludwig, 1903.—Koehler, 1917, 1920, 1923.—Verrill, 1914. (Not Ludwig, 1905=*Ampheraster*).—Fisher, 1922, p. 596; 1923. p. 605.

Parastichaster Koehler, Austral. Ant. Exp., 1920, p. 89. Type, *P. mawsoni* Koehler.

Diagnosis.—Small antarctic, or southern, paedophoric species with monacanthid adambulacral plates and typically a well-developed, irregularly reticulate abactinal skeleton, overlaid by a thin pulpy skin; carinals in more or less evident longiseries; dorsolateral plates usually rather numerous, forming an irrgular net, or arranged in subregular longiseries; superomarginals not relatively very broad; inferomarginal plates and spines not forming a sharp ventrolateral border to ray; crossed pedicallariae when numerous, aggregated around abactinal and marginal spinelets; straight pedicellariae usually lanceolate, sometimes robust, ovoid, or subspatulate; gonads open ventrally; a series of actinal plates, usually spiniferous, but absent in young specimens.

The relation of this group to *Anasterias* is discussed under that genus.

Parastichaster Koehler appears to represent the maximum development of skeleton. In addition to the 6-rayed type, Doctor Koehler describes two other species—*directus* having five rays and *sphaerulatus* with six or eight rays. These are all stout-armed, monacanthid sea stars, having a rather irregular dorsolateral skeleton, small carinals, and relatively much smaller superomarginals than has *Stichaster*, to which Koehler compares the genus. The gonads open ventrally and the young are carried in a cluster over the mouth. The stubby inferomarginal spines are arranged in short, oblique, transverse series.

All these features are characteristic of "*Sporasterias spirabilis*" (Bell) and adult "*S. rugispina*" (Stimpson). In fact *P. mawsoni* suggests a 6-rayed *Sporasterias spirabilis*. The paedophoric habit and monacanthid adambulacrals are outstanding common characters of *Sporasterias* and *Parastichaster*, and the genera seem to be confluent.

1. SPORASTERIAS ANTARCTICA (Lütken).

Asteracanthion antarcticum Lütken, Vidensk. Meddel., 1856, p. 105.

Asterias rugispina Stimpson, Proc. Boston Soc. Nat. Hist., vol. 8, 1860, p. 267.—Leipoldt, Zeit. Wiss. Zool., 1895, p. 563; literature.

Asterias cunninghami Perrier, Rév. Stell., 1875, p. 75.

Asterias spirabilis Bell, Proc. Zool. Soc., 1881, p. 513, pl. 48, fig. 4.

Asterias verrilli Bell, Proc. Zool. Soc., 1881, p. 513, pl. 47, figs. 3, 3*a*.

Asterias hyadesi Perrier, Comptes-rend., 1886, p. 1146.

Sporasterias spirabilis Perrier, Expéd. sci. Travailleur et Talisman, 1894, p. 107.

Asterias (*Sporasterias*) *antarctica* Meissner, Arch. Naturges, 1896, p. 105, pl. 6, figs. 7, 7*a*–7*b*; literature.

Sporasterias antarctica Ludwig, Expéd. antarct. Belge, 1903, p. 39; 1905*a*, p. 70.—Koehler, 1917, p. 10; 1920, p. 78, pl. 18, figs. 1–4; pl. 28, figs. 1–4; 1923, p. 14, pl. 7, fig. 4.

Anasterias antarctica Fisher, Ann. Mag. Nat. Hist., ser. 9, vol. 18, 1926, p. 197.

To this synonymy Leipoldt 1895, p. 563, adds: *Asteracanthion varium* Philippi, *A. fulgens* Philippi, as well as several species, such as *Anasterias minuta*, *Asterias perrieri* Smith, *Asterias rupicola* Verrill, and *Calvasterias stolidota* Sladen, which I consider to be distinct.

Among the above list of synonyms there are undoubtedly representatives of several well-marked formae, but material is lacking by which a scheme can be constructed.

Verrill (1914, p. 353), writes of this complex of forms as "the most common and abundant littoral and shallow-water starfishes of both coasts of Tierra del Fuego and Magellan Strait."

2. SPORASTERIAS PERRIERI (Smith).

Asterias perrieri SMITH, Ann. Mag. Nat. Hist., ser. 4, vol. 17, 1876, p. 106.

Kerguelen.

3. SPORASTERIAS RUPICOLA (Verrill).

Asterias rupicola VERRILL, Bull. U. S. Nat. Mus., vol. 3, 1881.

Kerguelen.

4. SPORASTERIAS MAWSONI (Koehler).

Parastichaster mawsoni KOEHLER, Austral. Ant. Exp., 1911–1914, vol. 8, pt. 1, 1920, p. 91, pl. 19, figs. 1–8; pl. 20, fig. 1; pl. 21, figs. 1–6; pl. 23, fig. 4; pl. 24, fig. 5; pl. 28, fig. 3; pl. 63, fig. 2.

Macquarie Island.

5. SPORASTERIAS DIRECTA (Koehler).

Parastichaster directus KOEHLER, 1920, p. 97, pl. 20, figs. 8–11; pl. 21, figs. 8–12; pl. 23, figs. 1, 2; pl. 62, fig. 2.

Macquarie Island.

6. SPORASTERIAS SPHAERULATA (Koehler).

Parastichaster sphaerulatus KOEHLER, 1920, p. 101, pl. 21, fig. 7; pl. 23, figs. 5–10; pl. 24, figs. 1–4; pl. 63, fig. 3; pl. 64, figs. 1, 2.

Macquarie Island.

Genus STICHASTER Müller and Troschel

Stichaster MÜLLER and TROSCHEL, Monatsber. Akad. Wiss. Berlin, 1840, p. 102; Arch. Naturges., Apr. 1840, p. 321. Type, *Asterias aurantiaca* Meyen (not Linnaeus) = *Stichaster striatus* Müller and Troschel.

Tonia GRAY, Ann. and Mag. Nat. Hist., Nov. 1840, p. 180. Type, *Tonia atlantica* Gray = *Stichaster striatus* Müller and Troschel.—PERRIER, Expéd. sci. Travailleur et Talisman, 1894, p. 129.

Coelasterias VERRILL, Trans. Conn. Acad., vol. 1, 1871 (1867), pt. 2, p. 247. Type, *Coelasterias australis* Verrill. See Fisher, 1922, p. 598.

Diagnosis.—Body covered with close-set, coarse, granuliform spinelets; carinal and superomarginal plates very short but broad; the latter conspicuously broader than inferomarginals which form a well-marked ventrolateral angle to ray and sometimes overhang the single series of small actinal plates; dorsolateral area broad, the plates in three to five series on each side of the carinals; adambulacral plates short, with two crowded spines, devoid of pedicellariae; crossed pedicellariae scattered, not in clusters or wreaths around abactinal spines; one madreporic body; interbrachial septa heavily calcified; gonoducts open dorsally, those of male with proximal swelling; not fissiparous.

1. STICHASTER STRIATUS Müller and Troschel.

Asterias aurantiaca MEYEN, Reise um die Erde, vol. 1, 1834, p. 222 (not Linnaeus).

Stichaster striatus MÜLLER and TROSCHEL, 1840*b*, p. 321.—VERRILL, 1914, p. 362.

Tonia atlantica GRAY, 1840, p. 180; Synopsis, 1866, p. 2.

Asteracanthion aurantiacus MÜLLER and TROSCHEL, Syst. der Asteriden, 1842, p. 21.

Stichaster aurantiacus VERRILL, 1867*a*, p. 293.—CLARK, Bull. Mus. Comp Zoöl., vol. 52, 1910, p. 337, pl. 8, fig. 1.

West coast of South America from Callao, Peru, to Talcahuano, Chile.

2. STICHASTER AUSTRALIS Verrill.

Coelasterias australis VERRILL, Trans. Conn. Acad., vol. 1, 1871 (1867), pt. 2, p. 247.—HUTTON, Catalog Echin. New Zealand, 1872, p. 5.—KOEHLER, 1920, pp. 54, 91.

Stichaster australis SLADEN, 1889, p. 431.—FARQUHAR, Trans. New Zeal. Inst., vol. 27, 1895, p. 202; Proc. Linn. Soc. New South Wales, 1898, p. 313.—FISHER, 1922, p. 598.—MORTENSEN, 1925, p. 313, pl. 14, figs. 1, 2; text figs. 17, 18.

New Zealand.

Genus UNIOPHORA Gray

Uniophora GRAY, Ann. and Mag. Nat. Hist., Dec. 1840, p. 288. Type, *Uniophora globifera* Gray=*Asterias granifera* Lamarck.

Diagnosis.—Typically 5-rayed, coarse-spined, heavy-ossicled, diplacanthid Australian forms with one to three series of actinal plates; abactinal skeleton with large, more or less irregular, meshes in two dorsolateral series on either side of the irregular carinal series; abactinal spines spaced, coarse, tuberculate, often capitate or globose and prominent; superomarginals with one to several capitate tubercular spines; inferomarginals with one to three spines; one well-defined, usually irregular, series of dorsolateral plates; adoral carina short, composed of one or two pairs of contiguous adambulacral plates, the first pair conspicuously longer than the second; numerous small, crossed pedicellariae are scattered along the skeletal ridges surrounding papular areas; straight pedicellariae inconspicuous, broadly lanceolate.

Some of the nine species listed below will ultimately, I think, be reduced to formae. Five species are from the South Australian coast, namely, *gymnota*, *multispina*, *nuda*, *obesa*, and *uniserialis*.

1. UNIOPHORA GRANIFERA (Lamarck).

Asterias granifera LAMARCK, Anim. sans verteb., vol. 2, 1816, p. 560.

Uniophora globifera GRAY, Ann. and Mag. Nat. Hist., Dec. 1840, p. 288.

Uniophora granifera BELL, Proc. Zool. Soc. London, 1881, p. 497.—FISHER, Ann. and Mag. Nat. Hist., ser. 9, vol. 18, 1926, p. 198.—CLARK, Rec. South Austral. Mus., vol. 3, No. 4, 1928, p. 403, fig. 117.

Tasmania.

I have examined Gray's types in the British Museum, and a specimen in the Paris Museum mentioned by Perrier (1875, p. 77), now labeled "*Pisaster graniferus*—Mers Australes, MM. Peron et Lesueur, 1803." I have two examples (one with six rays) from Port Jackson, New South Wales (U. S. National Museum).

2. UNIOPHORA DYSCRITA Clark.

Uniophora dyscrita CLARK, Journ. Linn. Soc. Zool., vol. 35, 1923, p. 244.

Western Australia: Garden Island, near Freemantle.

3. UNIOPHORA FUNGIFERA (Perrier).

Asterias fungifera PERRIER, Rév. Stell., 1875, p. 73.

Uniophora fungifera FISHER, Ann. and Mag. Nat. Hist., ser. 9, vol. 18, p. 198.—CLARK, 1928, p. 416.

I have examined the type, in the Museum d'Histoire Naturelle. It is labeled "Nouvelle Hollande, 1844, M. J. Verreaux."

4. UNIOPHORA GYMNOTA Clark.

Uniophora gymnota CLARK, Rec. South Austral. Mus., vol. 3, no. 4, 1928, p. 405, fig. 118.

South Australia: Spencer or St. Vincent Gulf.

5. UNIOPHORA MULTISPINA Clark.

Uniophora multispina Clark, Rec. South Austral. Mus., vol. 3, no. 4, 1928, p. 407, figs. 119*a*, 119*b*.

South Australia: Near Adelaide.

6. UNIOPHORA NUDA (Perrier).

Asterias nuda Perrier, Rév. Stell., 1875, p. 71.
Uniophora nuda Fisher, Ann. and Mag. Nat. Hist., ser. 9, vol. 18, 1926, p. 198.—Clark, 1928, p. 417.

I have examined the type which is from Port Lincoln, South Australia, R. B. Harvey, Esq. (British Museum); Perrier erroneously says that it is from Torres Strait.

7. UNIOPHORA OBESA Clark.

Uniophora obesa Clark, Rec. South Austral. Mus., vol. 3, No. 4, 1928, p. 409, fig. 120.

South Australia: Rocky Point, Eastern Cove, Kangaroo Island.

8. UNIOPHORA SINUSOIDA (Perrier).

Asterias sinusoida Perrier, Rév. Stell., 1875, p. 74.
Uniophora sinusoida Fisher, Ann. and Mag. Nat. Hist., ser. 9, vol. 18, p. 198.—Clark, Rec. South Austral. Mus., vol. 3, No. 4, 1928, p. 411, figs. 121*a*, 121*b*.

I have examined the type, in the British Museum, from Hobart, Tasmania. This may be a slender-spined form of *fungifera*.

9. UNIOPHORA UNISERIALIS Clark.

Uniophora uniserialis Clark, Rec. South Austral. Mus., vol. 3, No. 4, 1928, p. 413, figs. 122*a*, 122*b*.

South Australia: St. Vincent Gulf.

Subfamily NOTASTERIINAE Fisher

Genus NOTASTERIAS Koehler

Notasterias Koehler, British Antarctic Exp., vol. 2, pt. 4, 1911, p. 35. Type, *Notasterias armata* Koehler.—Fisher, 1923, p. 258.

Diagnosis.—With crossed pedicellariae of a peculiar type, sometimes of very large size, having hooked, terminally crossed jaws and usually broad base (*macrocephalous* Koehler) in addition to ordinary crossed and straight pedicellariae (including a peculiar large *pirocephalous* variety). Dorsal skeleton consisting of large, cruciform, spiniferous carinals (alternating sometimes with secondary smaller plates), to which short, transverse, sometimes sinuous, dorsolateral arcs of a few plates connect the superomarginals; a sporadically spiniferous plate in these arcs represents a poorly developed series of primary dorsolaterals. Marginals large, cruciform; one series of spiniferous actinal plates; two dorsolateral series of conspicuous papular areas on either side of carinal plates; one intermarginal; marginal and abactinal spines conspicuous, well spaced, not more than one to a plate, in longiseries, and devoid of a sheath carrying a collar of crossed pedicellariae; adambulacral plates diplacanthid proximally and monacanthid distally; or diplacanthid throughout, the spines without attached pedicellariae.

1. NOTASTERIAS ARMATA Koehler.

Notasterias armata Koehler, 1911, p. 39, pl. 5, figs. 6–11; pl. 6, figs. 1–8; 1912, p. 25, pl. 1, fig. 8; 1920, pl. 7, figs. 7–9; pl. 8, figs. 2–8; pl. 9, figs. 1–6; pl. 10, figs. 1–9; pl. 60, fig. 1; pl. 61, fig. 1.

South Victoria Land, 10 to 18 fathoms; Emperor Alexander Land, 297 meters; latitude 64° 32′ to 66° 55′ S.; longitude 92° to 145° 21′ E.; 60 to 354 fathoms.

2. NOTASTERIAS HASWELLI Koehler.

Notasterias haswelli Koehler, Australasian Anarctic Exped., vol. 8, pt. 1, 1920, p. 70, pl. 1, fig. 11; pl. 6, fig. 4; pl. 7, figs. 1–7; pl. 9, fig. 7; pl. 62, fig. 1.

Latitude 65° 42′ to 66° 50′ S.; longitude 92° 10′ to 142° 6′ E.; 60 to 354 fathoms.

Genus AUTASTERIAS Koehler

Autasterias Koehler, British Antarctic Exp., vol. 2, pt. 4, 1911, p. 35. Type, *Asterias pedicellaris* Koehler.—Fisher, 1923, p. 258.

Diagnosis.—In general structure similar to *Notasterias* but with monacanthid adambulacral plates.

1. AUTASTERIAS PEDICELLARIS (Koehler).

Asterias pedicellaris Koehler, Trans. Roy. Soc. Edinburgh, vol. 46, pt. 3, 1908, p. 577; pl. 7, figs. 61–67; pl. 8, figs. 74–78.

Latitude 71° 22′ S.; longitude 16° 34′ W.; 1,410 fathoms.

2. AUTASTERIAS BONGRAINI (Koehler).

Autasterias bongraini Koehler, Deux. Expéd. Ant. Française Échinod., 1912, p. 26, pl. 2, figs. 10, 11; 1920, p. 74, pl. 6, figs. 5–10; pl. 59, fig. 1.

South Shetland Islands, 420 meters; latitude 65° 42′ to 66° 55′ S.; longitude 92° 10′ to 145° 21′ E.; 60 to 318 fathoms.

LIST OF THE SPECIES NAMES APPLIED TO ASTERIINAE AND NOTASTERIINAE OF THE SOUTHERN HEMISPHERE

In the first column is given the species and original describer; in the second column, the original genus and date; in the third column, the genus to which the species has been assigned in the foregoing summary. Valid species names are in roman; synonyms in italics.

adeliae Koehler	Anasterias, 1920	Lysasterias.
alba Bell	Asterias, 1881	Diplasterias.
antarcticum Lütken	Asteracanthion, 1856	Sporasterias.
antarctica Koehler	Pisaster, 1917	Eremasterias.
armata Koehler	Notasterias, 1911	Notasterias.
atlantica Gray	Tonia, 1840	Stichaster.
asterinoides Perrier	Calvasterias, 1875	Calvasterias.
antipodum Bell	Calvasterias, 1882	Calvasterias.
aurantiaca Meyen	Asterias, 1834	Stichaster.
australis Verrill	Coelasterias, 1871	Stichaster.
belli Studer	Asterias, 1884	Diplasterias.
belgicae Ludwig	Anasterias, 1903	Lysasterias.
biseriatus Koehler	Granaster, 1906	Granaster.
bongraini Koehler	Autasterias, 1912	Autasterias.
borbonica Perrier	Asterias, 1875	Sporasterias.
brachiata Koehler	Saliasterias, 1920	Saliasterias.

brachiata Koehler	Cryptasterias, 1923	Cryptasterias.
brandti Bell	Asterias, 1881	Diplasterias.
brucei Koehler	Stolasterias, 1908	Diplasterias.
capensis Perrier	Asterias, 1875	Cosmasterias.
chirophora Ludwig	Anasterias, 1903	Lysasterias.
clavatum Philippi	Asteracanthion, 1870	Cosmasterias.
conferta Koehler	Kalyptasterias, 1923	Kalyptasterias.
cupulifera Ludwig	Anasterias, 1903	Lysasterias.
cunninghami Perrier	Asterias, 1875	Sporasterias.
dyscrita Clark	Cosmasterias, 1916	Cosmasterias.
dyscrita Clark	Uniophora, 1923	Uniophora.
directus Koehler	Parastichaster, 1920	Sporasterias.
felipes Sladen	Stichaster, 1889	Cosmasterias.
fochi Koehler	Podasterias, 1920	Diplasterias.
fragilis Studer		See p. 217.
fulgens Philippi	Asteracanthion, 1870	Sporasterias.
fulvum Philippi	Asteracanthion, 1870	Cosmasterias.
fungifera Perrier	Asterias, 1875	Uniophora.
georgiana Studer	Asterias, 1885	Neosmilaster.
germaini Philippi	Asteracanthion, 1858	Cosmasterias.
glomerata Sladen	Asterias, 1889	Diplasterias.
globifera Gray	Uniophora, 1840	Uniophora.
granifera Lamarck	Asterias, 1816	Uniophora.
gymnota Clark	Uniophora, 1928	Uniophora.
hartii Rathbun	Leptasterias, 1879	Allostichaster.
haswelli Koehler	Notasterias, 1920	Notasterias.
hebes Verrill	Stephanasterias, 1915	Allostichaster.
heptactis Clark	Perissasterias, 1926	Perissasterias.
hyadesi Perrier	Asterias, 1886	Sporasterias.
inaequalis Koehler	Allostichaster, 1923	Allostichaster.
induta Koehler	Diplasterias, 1908	Cryptasterias ?.
inermis Bell	Asterias, 1881	See p. 45.
irregularis Clark	Smilasterias, 1928	Smilasterias.
insignis Farquhar	Stichaster, 1895	Allostichaster.
joffrei Koehler	Paedasterias, 1920	Lysasterias.
lactea Ludwig	Anasterias, 1903	Lysasterias.
laevigata Hutton	Asterias, 1879	Calvasterias.
littoralis Farquhar	Stichaster, 1895	Calvasterias.
loveni Perrier	Diplasterias, 1881	Diplasterias.
luridum Philippi	Asteracanthion, 1858	Cosmasterias.
lütkeni Perrier	Diplasterias, 1891	Diplasterias.
lysasteria Verrill	Anasterias, 1914	Lysasterias.
meridionalis Perrier	Asterias, 1875	Diplasterias.
mawsoni Koehler	Parastichaster, 1920	Sporasterias.
minuta Perrier	Anasterias, 1875	Anasterias.
mite Philippi	Asteracanthion, 1870	Cosmasterias.
mollis Studer	Asterias, 1884	Diplasterias.
multispina Clark	Uniophora, 1928	Uniophora.
nautarum Bell (Sladen)	Asterias, 1889	See p. 24.
neglecta Bell	Asterias, 1881	Diplasterias.
neozealanica Farquhar	Tarsaster, 1895	Allostichaster.
nuda Perrier	Asterias, 1875	Uniophora.
nutrix Studer	Stichaster, 1885	Granaster.
octoradiata Koehler	Anasterias, 1914	Koehleraster.
obesa Clark	Uniophora, 1928	Uniophora.

obtusispina Clark	Perissasterias, 1926	Perissasterias.
obtusispinosa Bell	Asterias, 1881	Diplasterias.
papillosum Perrier	Asteroderma, 1891	Anasterias ?.
papillosa Koehler	Diplasterias, 1906	Adelasterias.
pedicellaris Koehler	Asterias, 1908	Autasterias.
pedicellaris Koehler	Sporasterias, 1923	Anasterias.
perrieri Smith	Asterias, 1876	Sporasterias.
perrieri Studer	Anasterias, 1885	Lysasterias.
philippii Bell	Asterias, 1881	See p. 62.
polygrammus Sladen	Stichaster, 1889	Cosmasterias.
polyplax Müller and Troschel	Asteracanthion, 1844	Allostichaster.
polyacantha Clark	Perissasterias, 1923	Perissasterias.
radiata Koehler	Cosmasterias, 1923	See p. 216.
regularis	Allostichaster, 1928	Allostichaster.
rugispina Stimpson	Asterias, 1860	Sporasterias.
rupicola Verrill	Asterias, 1881	Sporasterias.
scalprifera Sladen	Smilasterias, 1889	Smilasterias.
sinusoida Perrier	Asterias, 1875	Uniophora.
spectabile Philippi	Asteracanthion, 1870	Cosmasterias.
sphaerulatus Koehler	Parastichaster, 1920	Sporasterias.
spirabilis Bell	Asterias, 1881	Sporasterias.
spinosa Perrier	Diplasterias, 1891	See p. 216.
steineni Studer	Asterias, 1885	Neosmilaster.
stolidota Sladen	Calvasterias, 1889	Calvasterias.
striatus Müller and Troschel	Stichaster, 1840	Stichaster.
studeri Bell	Asterias, 1881	Diplasterias.
studeri Perrier	Anasterias, 1891	Lysasterias.
studeri de Loriol	Gastraster, 1904	Cosmasterias.
sulcifer Perrier	Asteracanthion, 1869	Cosmasterias.
suteri de Loriol	Stichaster, 1894	Calvasterias.
tenera Koehler	Anasterias, 1906	Lysasterias.
terwieli Goldschmidt	Smilasterias, 1924	See p. 217.
tomidata Sladen	Cosmasterias, 1889	Cosmasterias.
triremis Sladen	Smilasterias, 1889	Smilasterias.
turqueti Koehler	Diplasterias, 1906	Cryptasterias.
uniserialis Clark	Uniophora, 1928	Uniophora.
varium Philippi	Asteracanthion, 1870	Sporasterias.
verrilli Bell	Asterias, 1881	Sporasterias.
vesiculosa Sladen	Asterias, 1889	Bathyasterias.
victoriae Koehler	Coscinasterias, 1911	Diplasterias.
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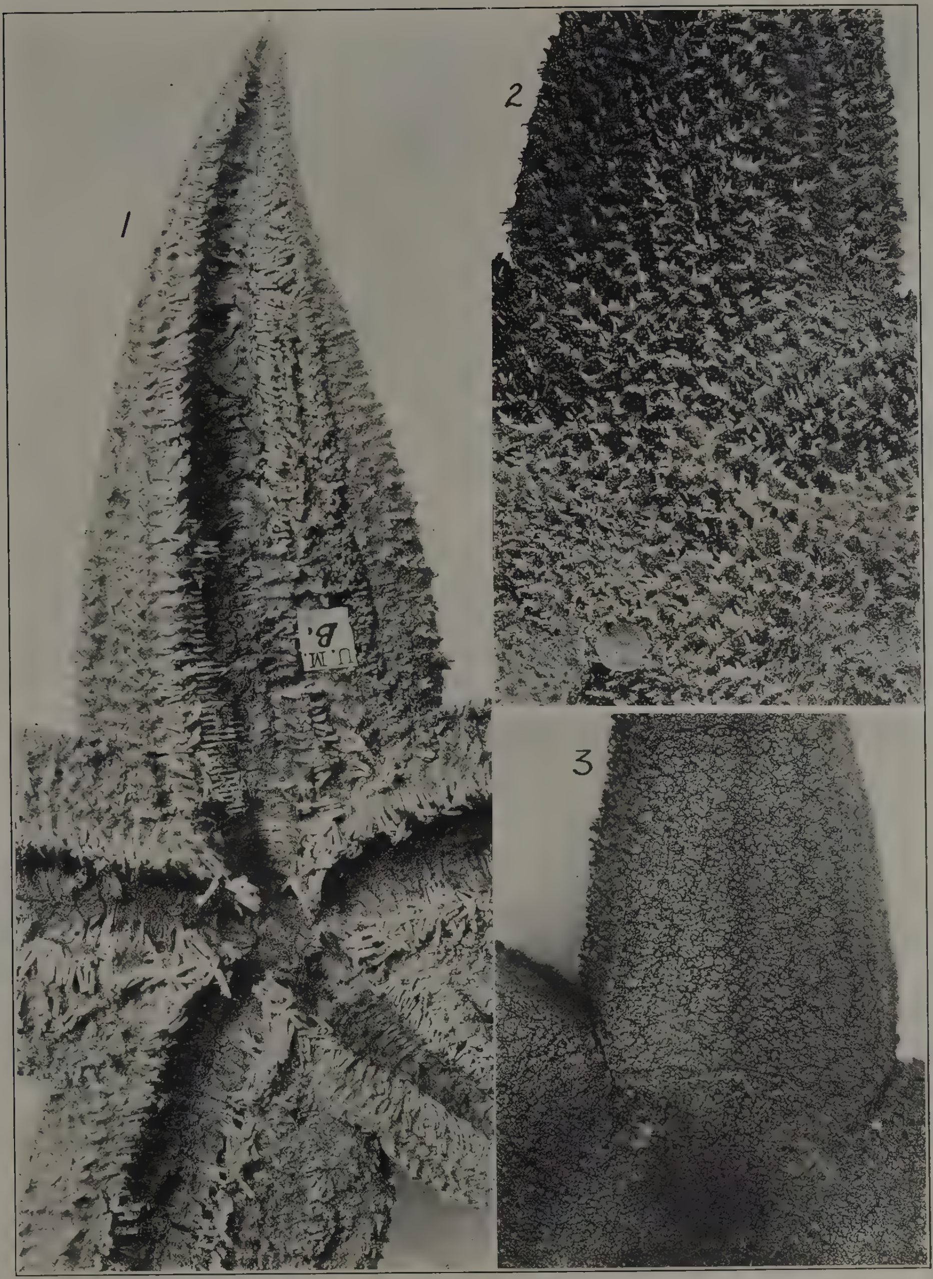
EXPLANATION OF PLATES

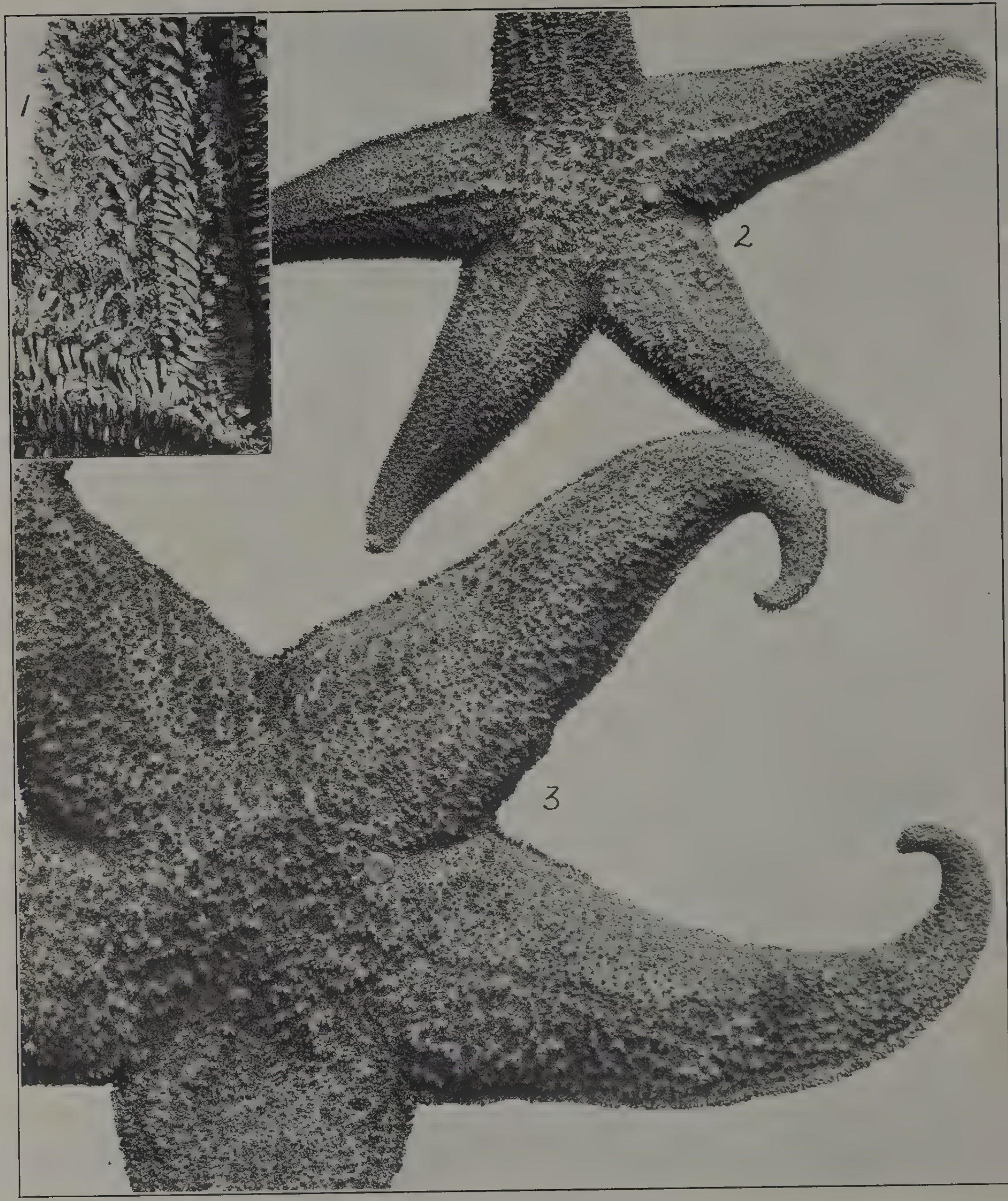
Plate 1

Figure 1. *Asterias amurensis*, cotype; Amur country, eastern Asia; actinal surface, enlarged.
2. Same specimen; portion of abactinal surface, enlarged.
3. Same, Petropavlovsk, Kamchatka; portion of abactinal surface, natural size, alcoholic specimen.



ASTERIAS AMURENSIS

For explanation of plate see page facing.



ASTERIAS AMURENSIS

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 2

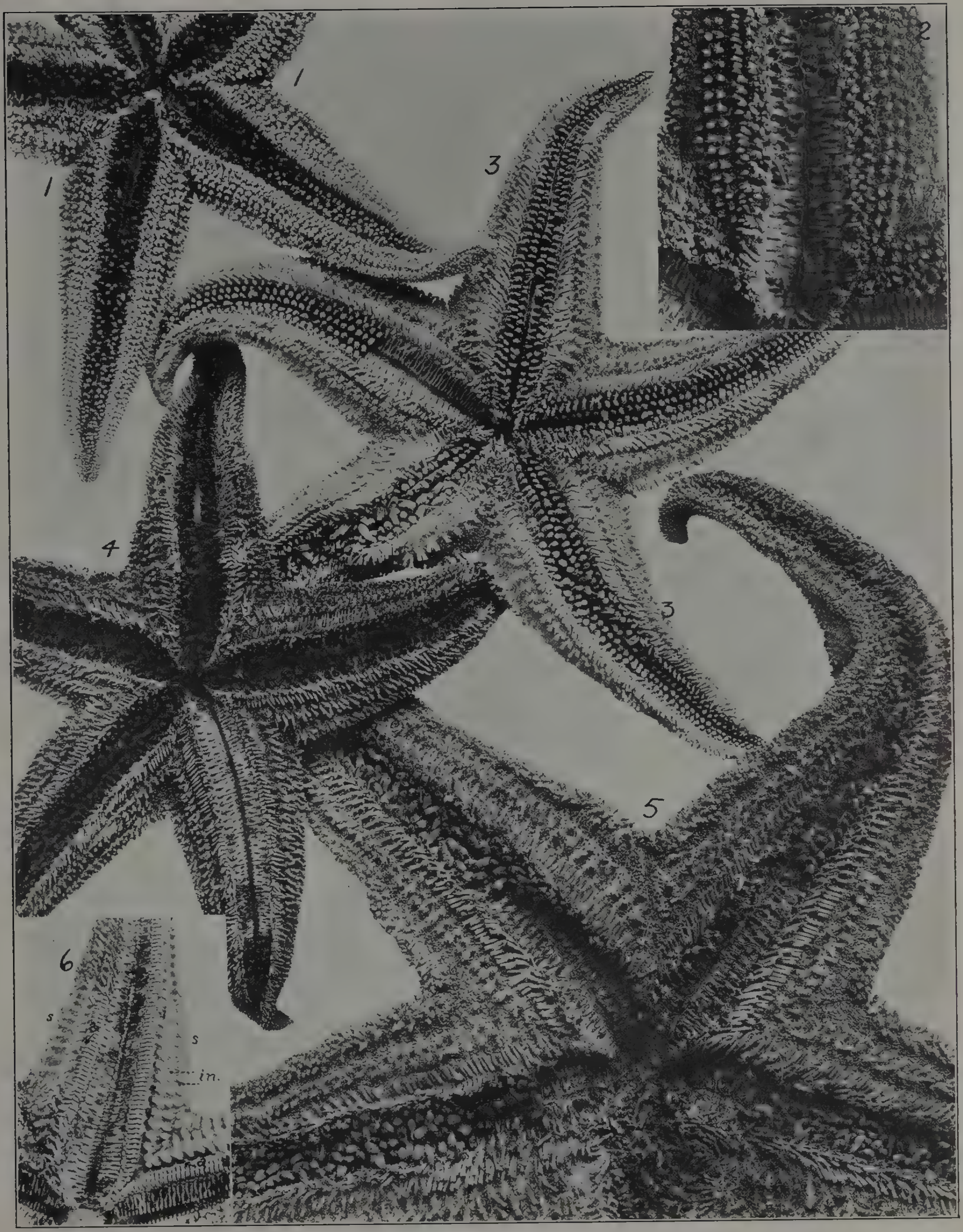
FIGURE 1. *Asterias amurensis*, station 3242, same specimen as Figure 3; portion of actinal surface, enlarged.

2. Same, No. 7631, Norton Sound, Alaska, $\times \frac{4}{5}$.
3. Same, station 3242, $\times \frac{4}{5}$. Specimen upon which description is based.

PLATE 3

FIGURE 1. *Asterias amurensis* forma *anomala,* station 3231; actinal surface, reduced.

2. *Asterias amurensis* forma *amurensis,* Petropavlovsk, Kamchatka; portion of actinal surface, alcoholic specimen.
3. Same, Petropavlovsk, Kamchatka.
4. Same, No. 7631, Norton Sound, Alaska.
5. Same, station 3242, actinal surface of Plate 2, Figure 1.
6. Same, station 3243, actinal surface of a medium-sized specimen showing arrangement of plates; *a,* actinal (rudimentary); *i,* inferomarginal; *in,* intermarginal (two series); *s,* superomarginal.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ASTERIAS AMURENSIS

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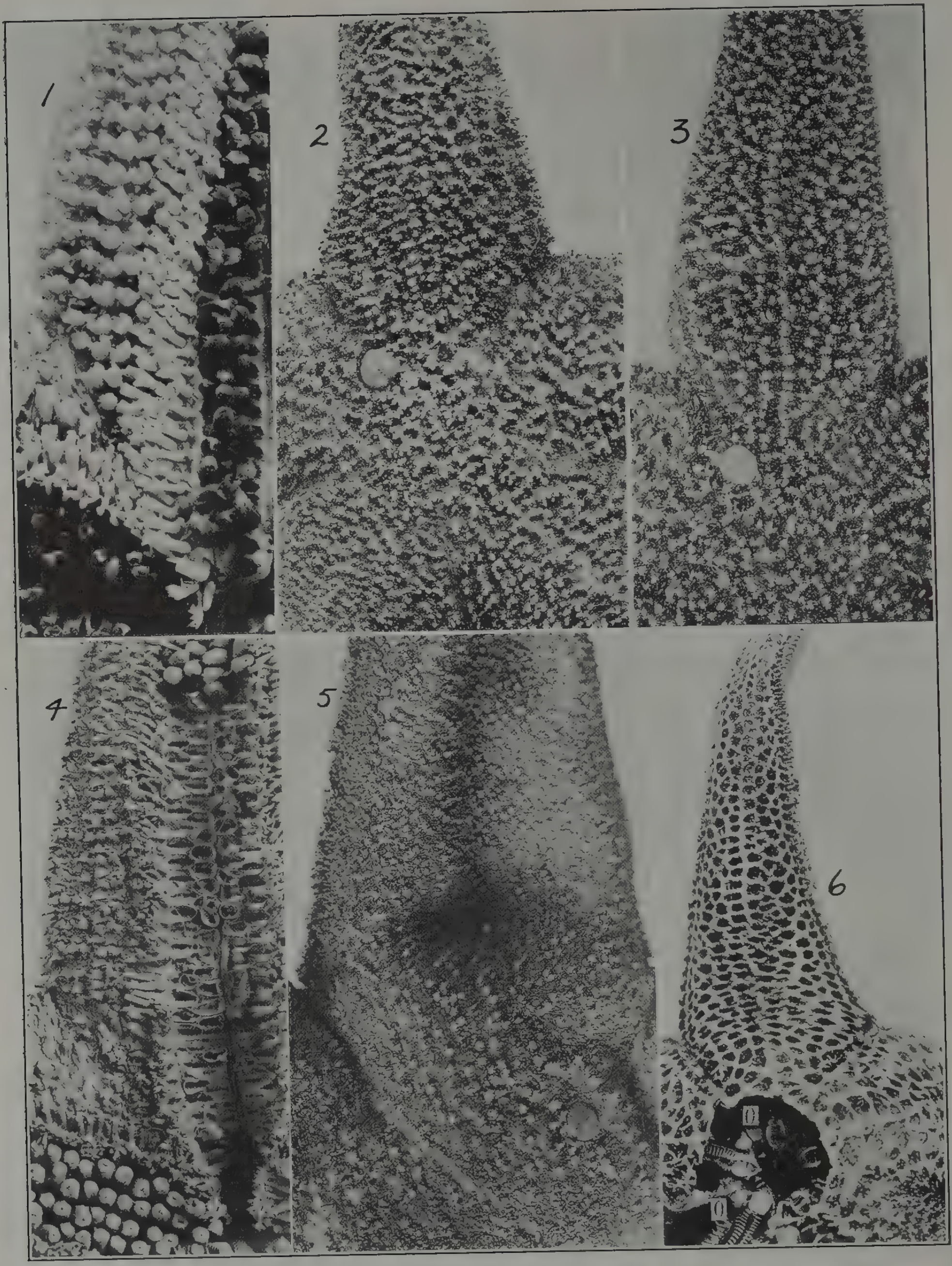


Asterias amurensis

For explanation of plate see page facing.

Plate 4

Figure 1. *Asterias amurensis* forma *anomala*, station 3231; portion of actinal surface, enlarged.

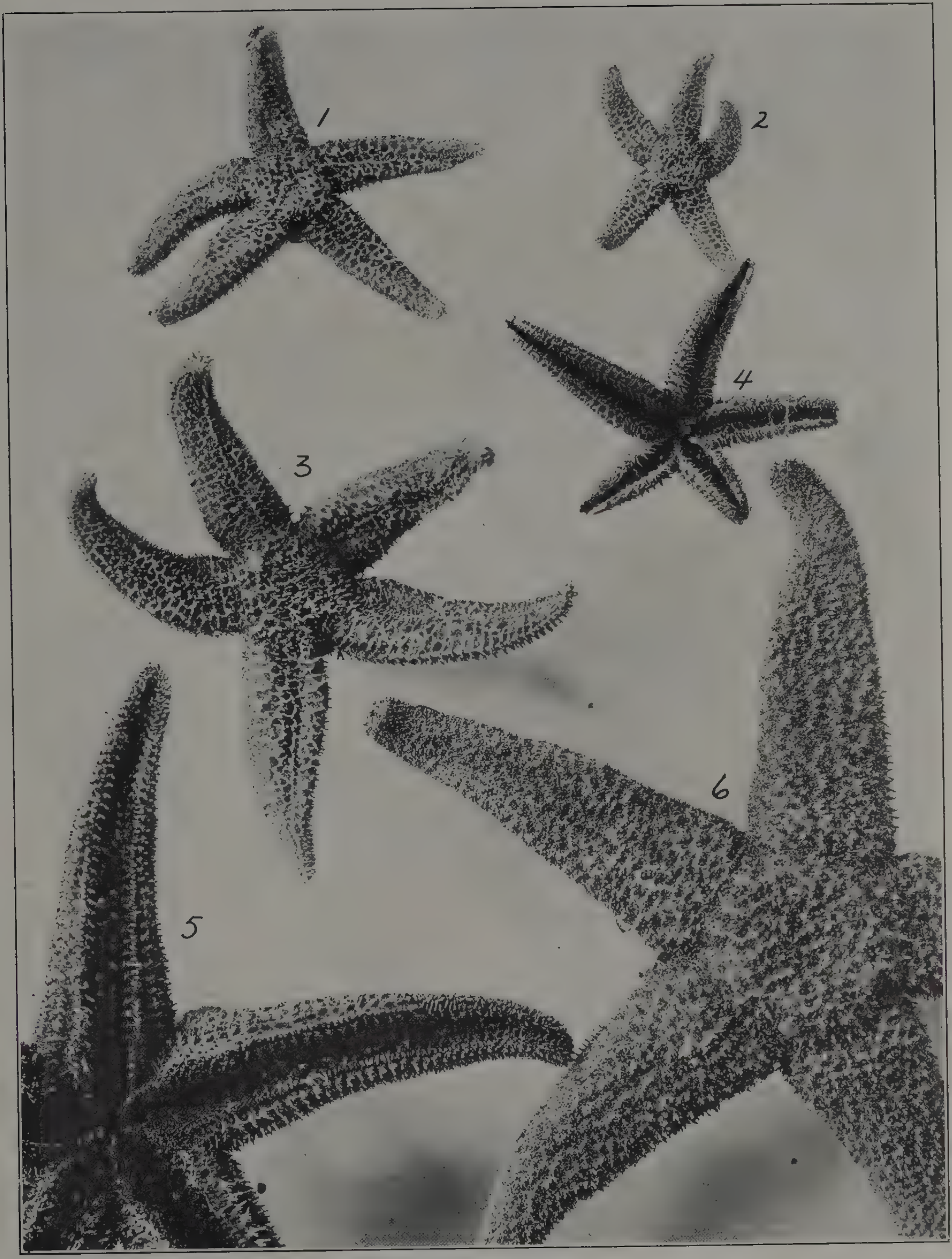
2. Same, station 3231; abactinal surface.
3. Same, station 3231; abactinal surface of specimen with well-defined series of carinal spines.
4. *Asterias amurensis* forma *amurensis*, station 3335, 93 fathoms, alcoholic specimen.
5. Same specimen, abactinal surface.
6. Same, station 3243; medium-sized specimen, with dorsal skeleton cleaned and a portion removed to show actinostomial ring; *o*, odontophore.

PLATE 5

Specimens to show growth stages; ×2

FIGURES 1–3. Station 3241.
4–6. Petropavlovsk, Kamchatka.

NOTE.—Young specimens are easily mistaken for *Leptasterias*.



ASTERIAS AMURENSIS

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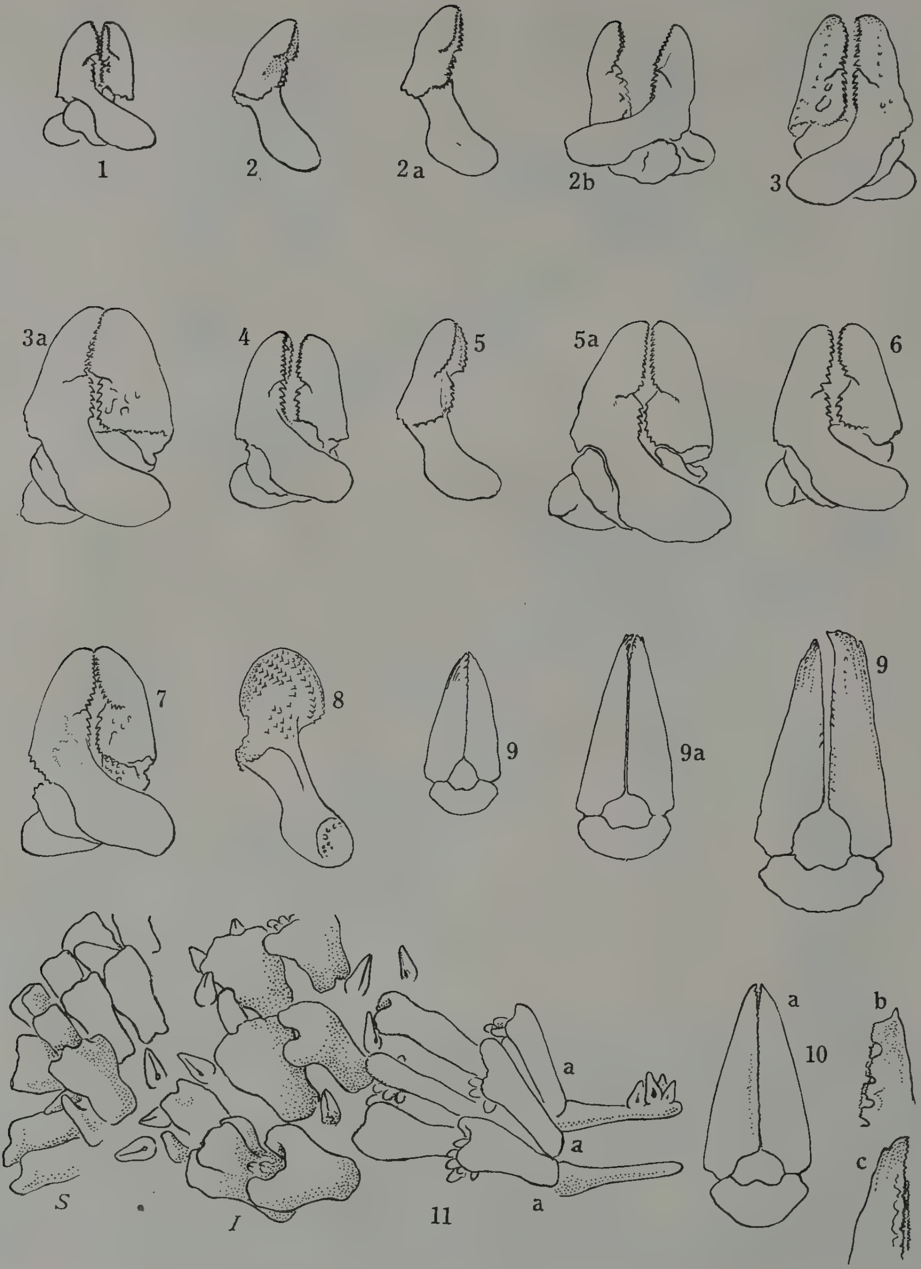
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1, 9. ASTERIAS AMURENSIS ROLLESTONI. 2–8, 10, 11. A. AMURENSIS AND FORMAE

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 6

FIGURE 1. *Asterias amurensis rollestoni*, Mororan, Hokkaido. Abactinal crossed pedicellaria, 0.21 mm., ×100.

2. *Asterias amurensis* forma *amurensis*, cotype, Amur. From an abactinal spine, ×100.

2*a*, 2*b*. From inferomarginal spines, 0.26 mm., ×100.

3. Same, from inferomarginal spine of a Petropavlovsk specimen, with R 87 mm.; pedicellaria 0.32 mm., ×100.

3*a*. From inferomarginal spine of largest Petropavlovsk specimen (R 130 mm.), ×100.

4. Same, from inferomarginal spine of Norton Sound specimen, 0.27 mm., ×100.

5. *Asterias amurensis* forma *anomala*, station 3231; from an abactinal spine, 0.27 mm., ×100.

5*a*. Station 3231; from an inferomarginal spine, 0.36 mm., ×100.

6. Same, Cape Lisburne specimen; from an inferomarginal spine, 0.3 mm., ×100.

7. *Asterias amurensis* forma *amurensis*, station 3225, 85 fathoms; from an inferomarginal spine, 0.34 mm., ×100.

8. Same, station 3335, 90 fathoms; from inferiomarginal spine, 0.36 mm., ×100.

9. *Asterias amurensis rollestoni*, Mororan, Hokkaido. Abactinal straight pedicellariae, 0.5 mm., ×50.

9*a*. From actinal surface, 0.72 mm., ×50.

9*b*. From a furrow spine, 0.45 mm., ×100.

10. *Asterias amurensis* forma *amurensis*, cotype, Amur; *a*, an intermarginal straight pedicellaria, 0.75 mm., ×50; *b*, *c*, the tips of two jaws, ×100.

11. *Asterias amurensis* forma *anomala*, station 3231; a segment across actinal surface, on basal third of ray; *S*, superomarginals; *I*, inferomarginals; *a*, *a*, *a*, three adambulacral plates.

PLATE 7

FIGURE 1. *Asterias amurensis* forma *amurensis*, Norton Sound; a straight pedicellaria from a furrow spine, 0.67 mm., ×100.

1*a*. An abactinal pedicellaria, 0.43 mm., ×100.

2. *Asterias amurensis* forma *anomala*, station 3231; an actinal pedicellaria, 0.76 mm., ×50.

2*a*. Tip of an actinal pedicellaria, ×100.

2*b*. A pedicellaria from a furrow spine, ×100.

2*c*. Two abactinal spinelets, upper 1.25 mm., lower 1.08 mm., ×15.

2*d*. Two inferomarginal spines, 2 mm., ×15.

3. *Asterias amurensis* forma *amurensis*, station 3250, 17.5 fathoms; actinal pedicellaria, ×50.

4. Forma *anomala*, Cape Lisburne, Arctic Ocean; *a*, an actinal pedicellaria, 0.9 mm., ×50; *b*, tip of one jaw; *c*, tip of two jaws, ×100.

5. *Asterias amurensis* forma *amurensis*, cotype, Amur Province. Abactinal spinelet, 1.2 mm., ×25.

5*a*. Adambulacral armature from furrow face, ×10.

6. Same, Petropavlovsk, largest specimen, R 130 mm.; armature of three consecutive adambulacral plates near the base of ray, ×5.

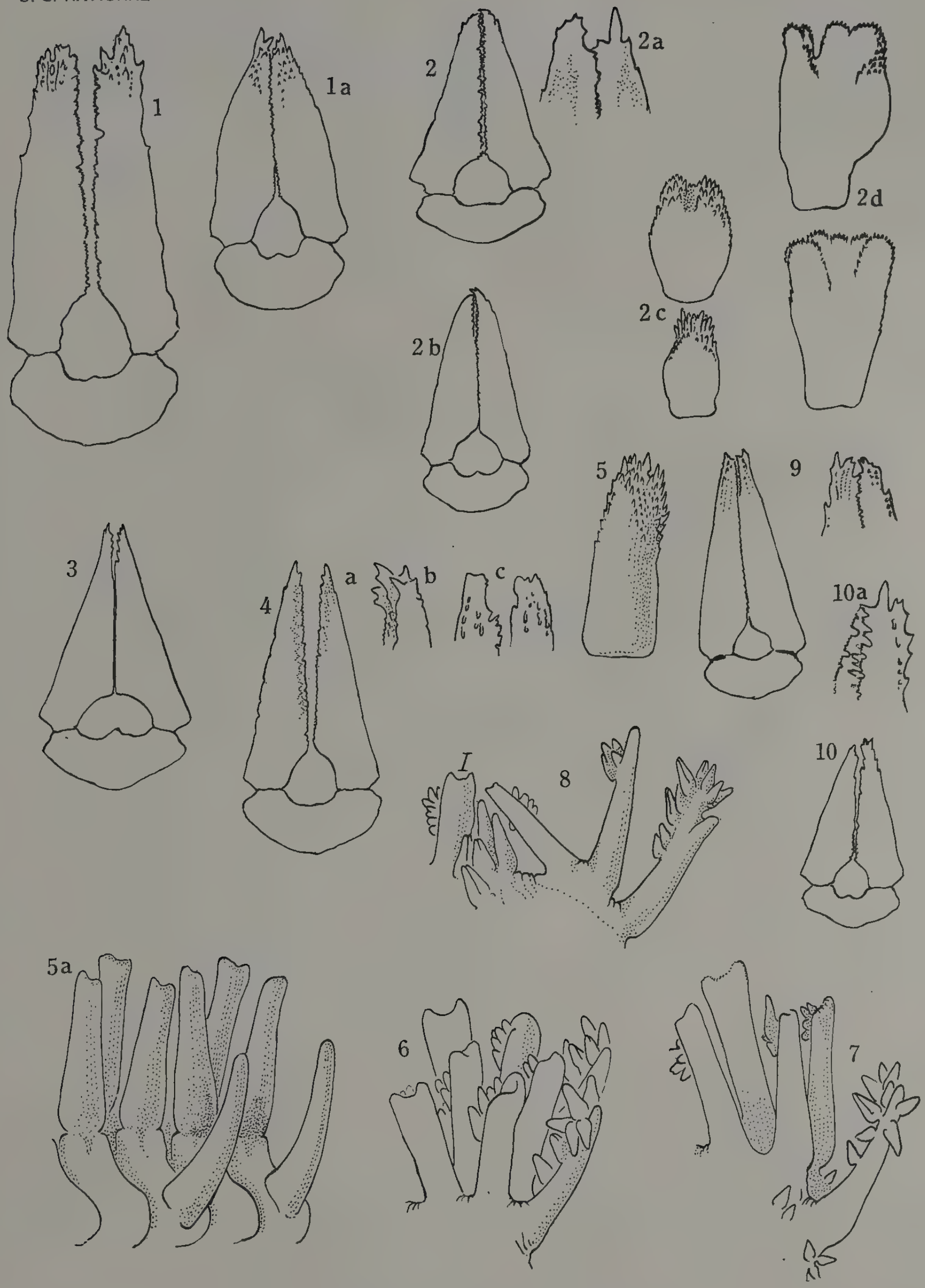
7. Same, station 3242, two consecutive adambulacral plates, ×5. This is the specimen upon which the account is based.

8. Same, specimen from station 3335, 93 fathoms; adambulacral armature and an inferomarginal spine, *I*, ×5.

9. Same, Petropavlovsk, an actinal straight pedicellaria, 0.76 mm., ×50; and tip of another, ×100.

10. Same, station 3225, 85 fathoms; an actinal straight pedicellaria, 0.63 mm., ×50.

10*a*. A tip, ×150.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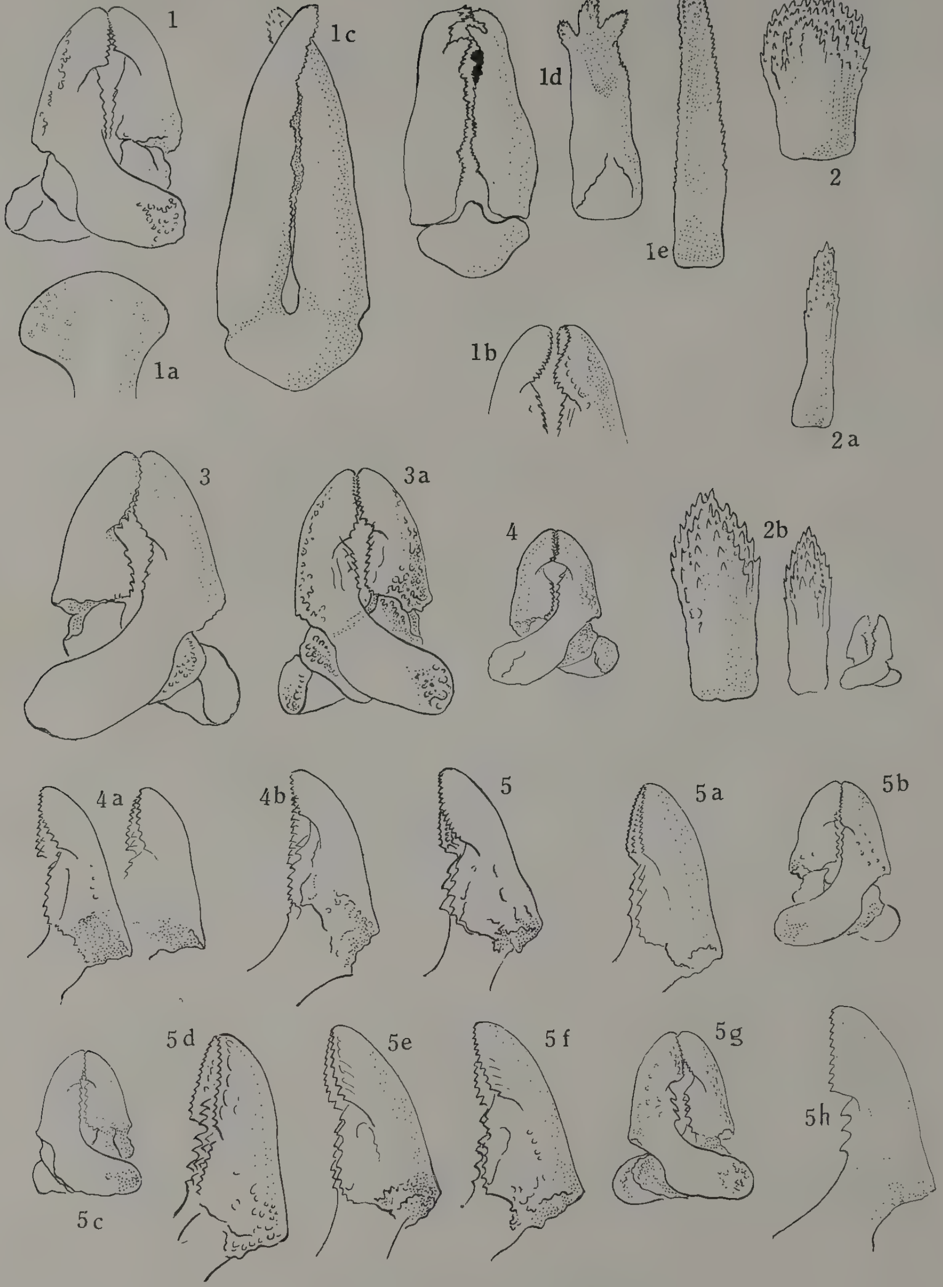
ASTERIAS AMURENSIS AND FORMAE

FOR EXPLANATION OF PLATE SEE PAGE FACING.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1-3. Leptasterias groenlandica. 4. L. mülleri. 5. L. arctica

For explanation of plate see page facing.

PLATE 8

FIGURE 1. *Leptasterias groenlandica;* an abactinal crossed pedicellaria of forma *cribraria*, station 3252, 0.21 mm., ×200.

1*a*. Station 3537, end of a blade, ×200.

1*b*. Station 3506, forma *groenlandica;* end of a crossed pedicellaria, ×200.

1*c*. Station 3506, forma *groenlandica;* a very large axillary straight pedicellaria, 1.20 mm., ×50

1*d*. Station 3352, forma *cribraria;* an intermarginal straight pedicellaria and an inside view of a jaw, 0.8 mm., ×50.

1*e*. Jaw of the slender lanceolate sort, ×50.

2. *Leptasterias groenlandica* forma *cribraria*, station 3252, abactinal spinelet, 0.52 mm., ×50

2*a*. Station 3530, abactinal spinelet, 0.55 mm., ×50.

2*b*. Station 3506, two abactinal spines (forma *groenlandica*) with pedicellaria drawn to scale, longer spine 0.6 mm., ×50.

3. *Leptasterias groenlandica*, off Cape York, west coast of Greenland; an abactinal crossed pedicellaria, 0.225 mm., ×200. Similarly shaped adambulacral spine pedicellariae are 0.27 mm. long.

3*a*. Same, Jugor Strait, off Kara Sea, north of Siberia. An abactinal pedicellaria, 0.2 mm., ×200.

4. *Leptasterias mülleri*, northwest of Bergen, 90–200 fathoms, slender rays; abactinal pedicellaria, Riksmuseum No. 751, ×100.

4*a*. Same, two jaws, Waideguba, 40 fathoms, Riksmuseum, No. 745, ×200.

4*b*. Same, side view of jaw, northwest of Bergen, Riksmuseum, No. 751, ×200.

5. *Leptasterias arctica* forma *arctica*, cotype, Point Franklin; jaw of abactinal pedicellaria, ×200.

5*a*. Same (0.26 mm.), ×200.

5*b*. Same, ×100.

5*c*. Same, Plover Bay (0.23 mm.), ×100.

5*d*. Same, ×200.

5*e*. Same, specimen from station 3559, intermediate between forma *arctica* and forma *beringensis*, length 0.27 mm., ×200.

5*f*. *L. arctica* forma *beringensis*, type, station 3277, abactinal, ×200.

5*g*. Same, station 3294, 0.27 mm., ×100.

5*h*. Same, station 3294, outside of jaw, side view, ×200.

PLATE 9

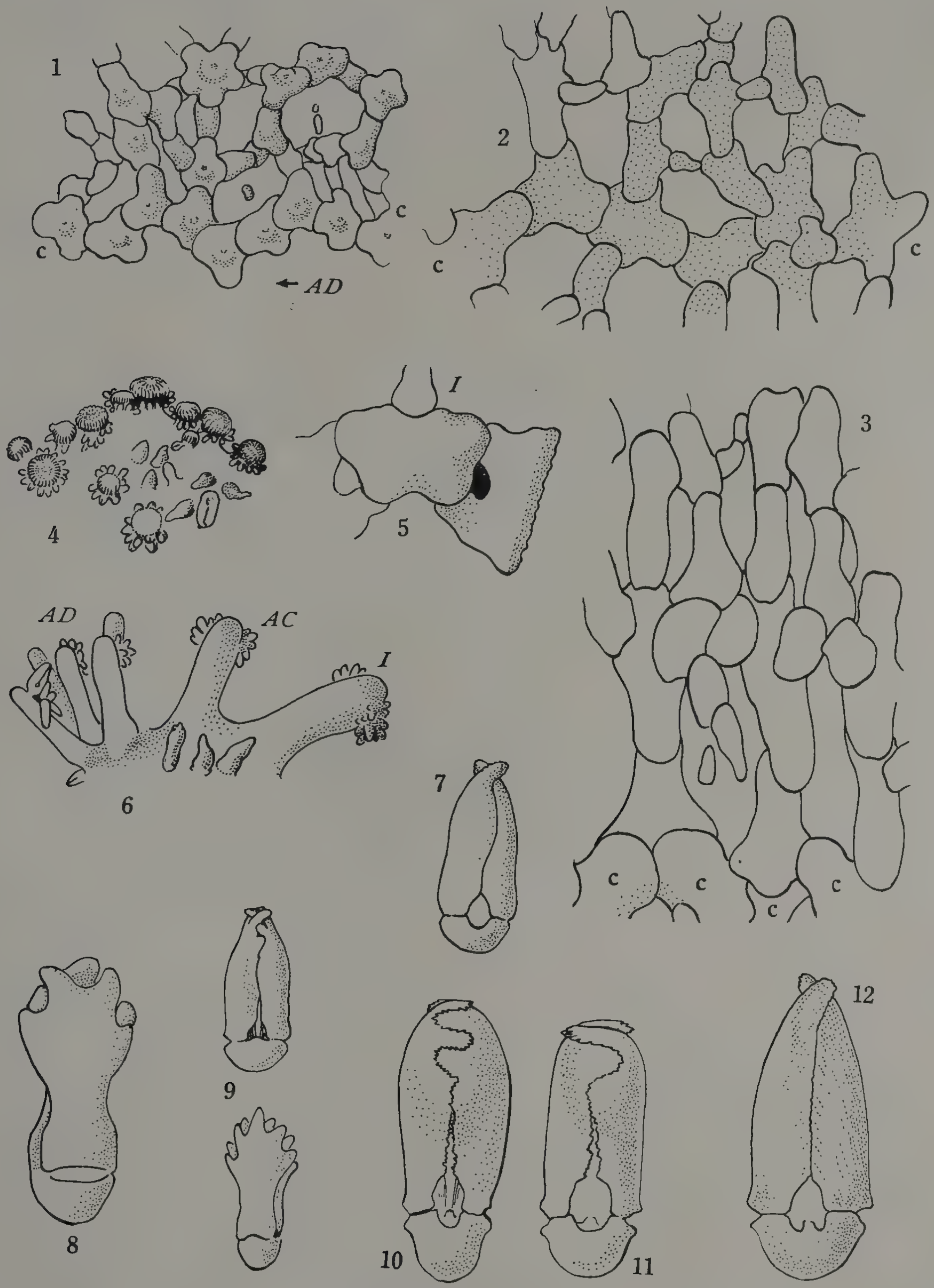
Leptasterias arctica

FIGURE 1. Station 3294, forma *beringensis*, abactinal skeleton, external view, ×5. The lowermost row of plates (*c–c*) are the carinals; *AD*, direction of disk.

2. Specimen from northern Bering Sea, forma *arctica;* abactinal skeleton from coelomic side; *c–c*, carinal series; ×10.
3. Station 3504, forma *beringensis;* abactinal skeleton, from coelomic side. This specimen has a heavier skeleton than Figure 2; *c–c* carinal plates; ×10.
4. Station 3536, forma *beringensis;* specimen with robust rays. Small portion of abactinal surface showing carinal spines, ×5.
5. Station 3512, forma *beringensis;* odontophore from above; *I*, interradial septum; ambulacral ossicles on either side; ×10.
6. Station 3536, forma *beringensis;* adambulacral, actinal, and inferomarginal spines; three consecutive adambulacral series are shown; *AD*, adambulacral; *AC*, actinal; *I*, inferomarginal; ×10.
7. Forma *arctica*, straight pedicellaria from a suboral spine, cotype, ×50.
8. Forma *arctica*, an unguiculate pedicellaria from actinal interradial region, cotype, ×50.
9. Station 3543, forma *beringensis;* two views of an actinal interradial or axillary pedicellaria, ×25.

10, 11. Station 3543, forma *beringensis;* two unguiculate abactinal pedicellariae, the larger 0.9 mm. long, ×50.

12. Station 3543, forma *beringensis;* a straight pedicellaria from furrow face of adambulacral plate, ×100.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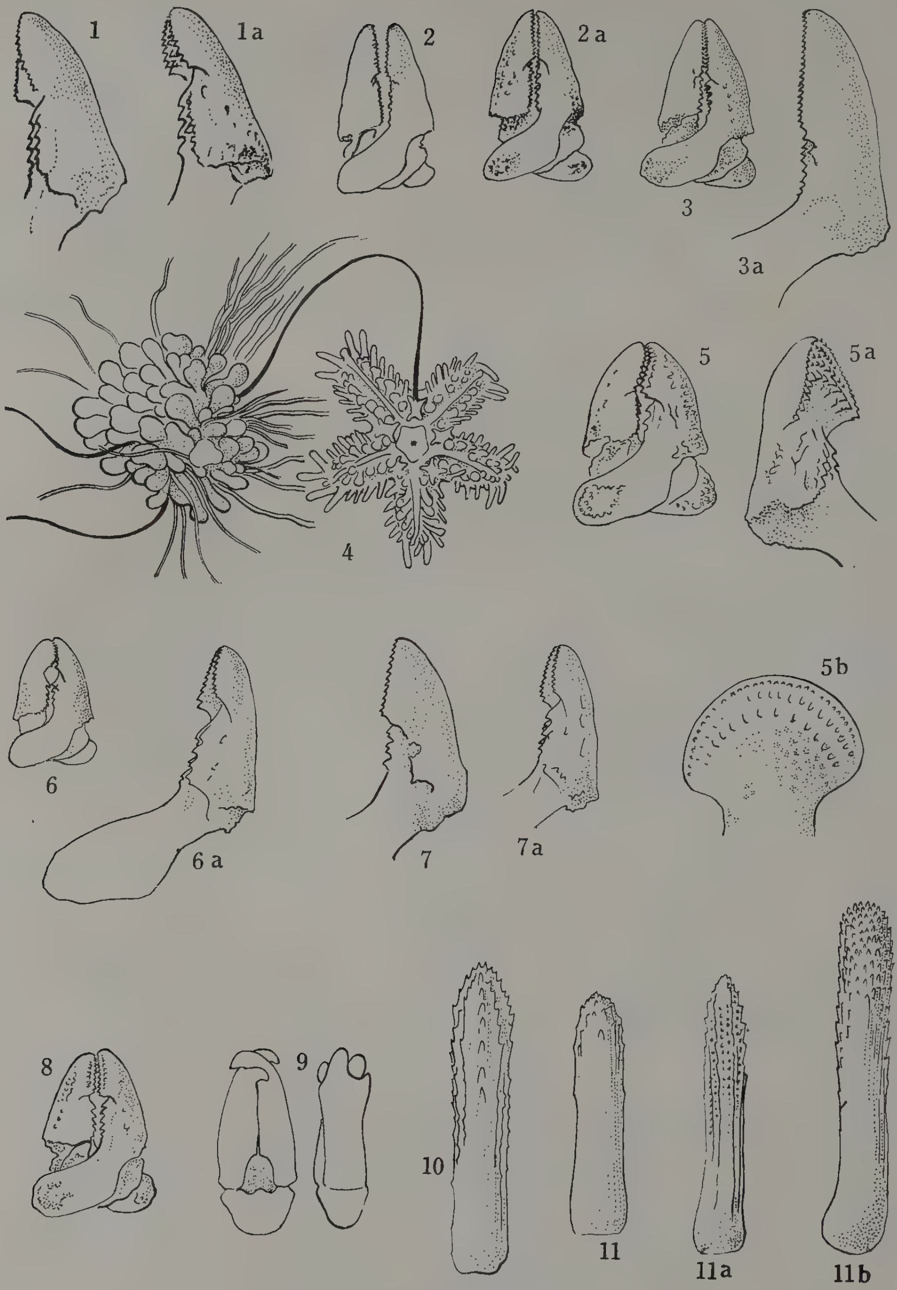
Leptasterias arctica

For explanation of plate see page facing.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1-4. Leptasterias arctica. 5-11. L. hylodes

For explanation of plate see page facing.

PLATE 10

FIGURE 1. *Leptasterias arctica* forma *beringensis*, station 3514, abactinal pedicellaria, ×200. 1*a* Same, Nazan Bay, Atka, ×200.

2, 2a. *Leptasterias arctica* forma *arctica*, cotype, Point Franklin, two pedicellariae from furrow spines 0.26 mm., ×100.

3. *Leptasterias arctica* forma *beringensis*, station 3294, pedicellaria from furrow spine, 0.27 mm., ×100.

3*a*. Same, jaw, ×200.

4. *Leptasterias arctica* forma *beringensis;* young from brood "pouch" of female, showing attachment to common central lobulate mass. Numerous strands without young are shown issuing from the mass.

5. *Leptasterias hylodes*, station 2847, abactinal pedicellaria from large specimen, length 0.275 mm., ×100.

5*a*. Same, one jaw, ×200.

5*b*. Same, tip of jaw, ×200.

6. Same, dwarf form, station 2856, abactinal pedicellaria, ×100.

6*a*. A jaw, ×200.

7. Same, station 2856; jaw of a furrow-spine pedicellaria, ×200.

7*a*. Station 2856; an adambulacral pedicellaria similar to the abactinal, ×200.

8. Same, type (station 2851), an abactinal pedicellaria, ×100.

9. Same, station 2847; an axillary unguiculate pedicellaria from actinal interradial region, 1.15 mm., ×25.

10. Same, type (station 2851); a dorsal spine, 0.98 mm., ×50.

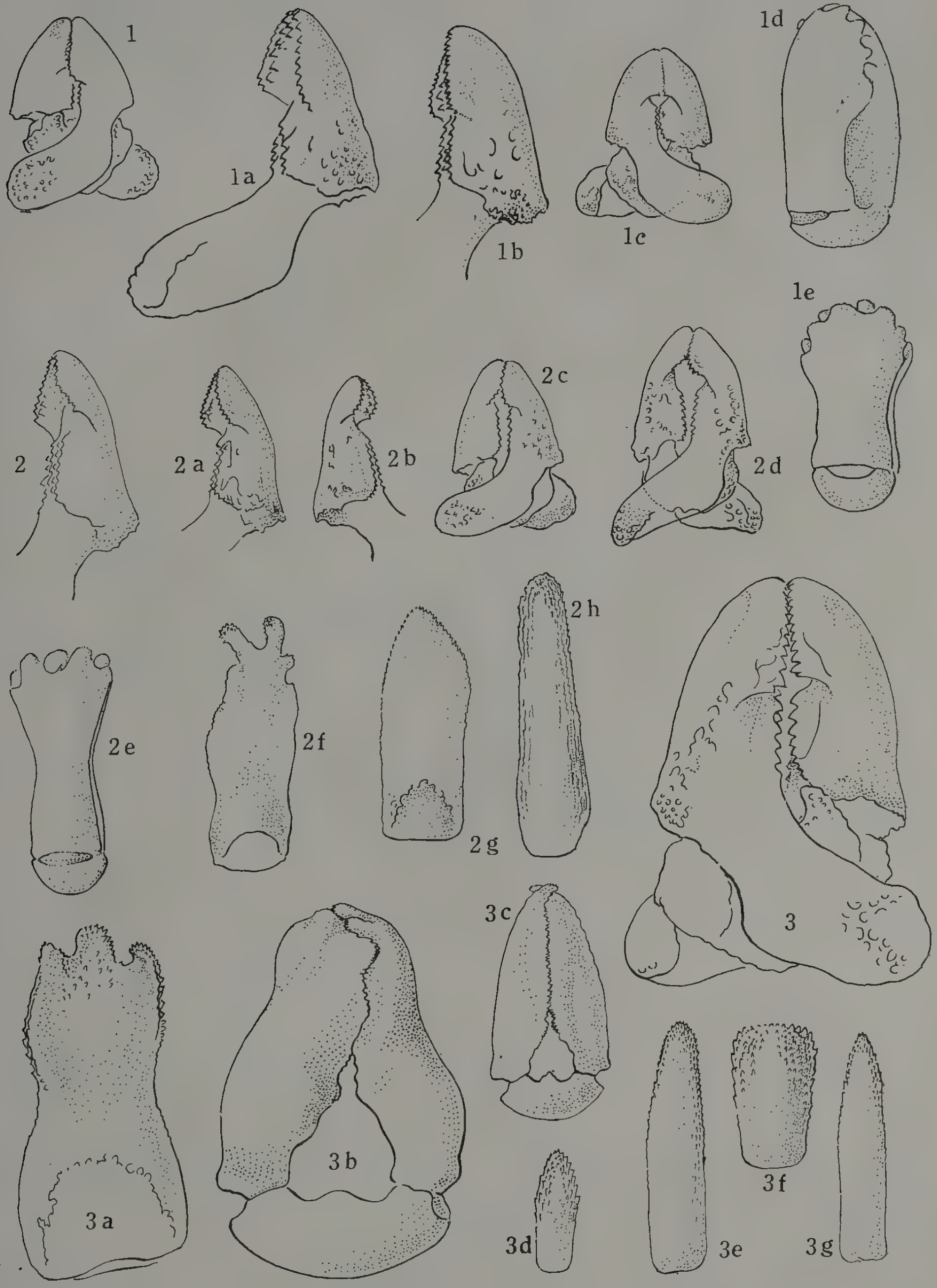
11. Same, station 2856; dwarf form, abactinal spinelet, 0.76 mm., ×50.

11*a*. Same specimen, a superomarginal spine, ×50.

11*b*. Same, a furrow spine, ×50.

PLATE 11

FIGURE 1. *Leptasterias hyperborea*, Icefjord, Spitzbergen, abactinal pedicellaria, ×100.
1*a*. One jaw, Riksmuseum, No. 124, ×200.
1*b*. Same, Cross Bay, Spitzbergen; jaw of abactinal pedicellaria, Riksmuseum, No. 330, ×200.
1*c*. Same, abactinal pedicellaria, Riksmuseum, No. 726, ×100.
1*d*, 1*e*. Icefjord, Spitzbergen, Riksmuseum, No. 124, ×50; 1*d*, marginal 0.75 mm.; 1*e*, abactinal, 0.67 mm.
2. *Leptasterias orientalis*, station 5024, abactinal crossed pedicellaria, 0.24 mm., ×200.
2*a*. Same, station 4810 (see text).
2*b*. Closely related race from station 5047, off Bay of Sendai (see text).
2*c*. *Orientalis*, station 5024; abactinal pedicellaria, 0.27 mm., ×100.
2*d*. Same, Okhotsk Sea, 57° 36′ N., 140° 34 E.; abactinal pedicellaria, 0.31 mm.
2*e*. Same, station 5024; straight pedicellaria 0.8 mm., ×50.
2*f*, 2*g*. Same, jaws of two straight pedicellariae from actinal interradial area of example upon which description is based, ×50.
2*h*. Same, station 5024, carinal spinelet, 0.9 mm., ×50.
3. *Leptasterias fisheri*, Okhotsk Sea; abactinal pedicellaria, 0.32 mm., ×200.
3*a*. Same, one jaw of an actinal axillary pedicellaria, ×50.
3*b*. Side view of a similar pedicellaria, 1.17 mm. long, ×50.
3*c*. Same, pedicellaria from an adambulacral spine, 0.7 mm., ×50.
3*d*. A dorsolateral spinelet, 0.9 mm., ×20.
3*e*. An inferomarginal spinelet, ×20.
3*f*. A carinal spinelet, ×20.
3*g*. A superomarginal spinelet, ×20.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1. LEPTASTERIAS HYPERBOREA. 2. L. ORIENTALIS. 3. L. FISHERI

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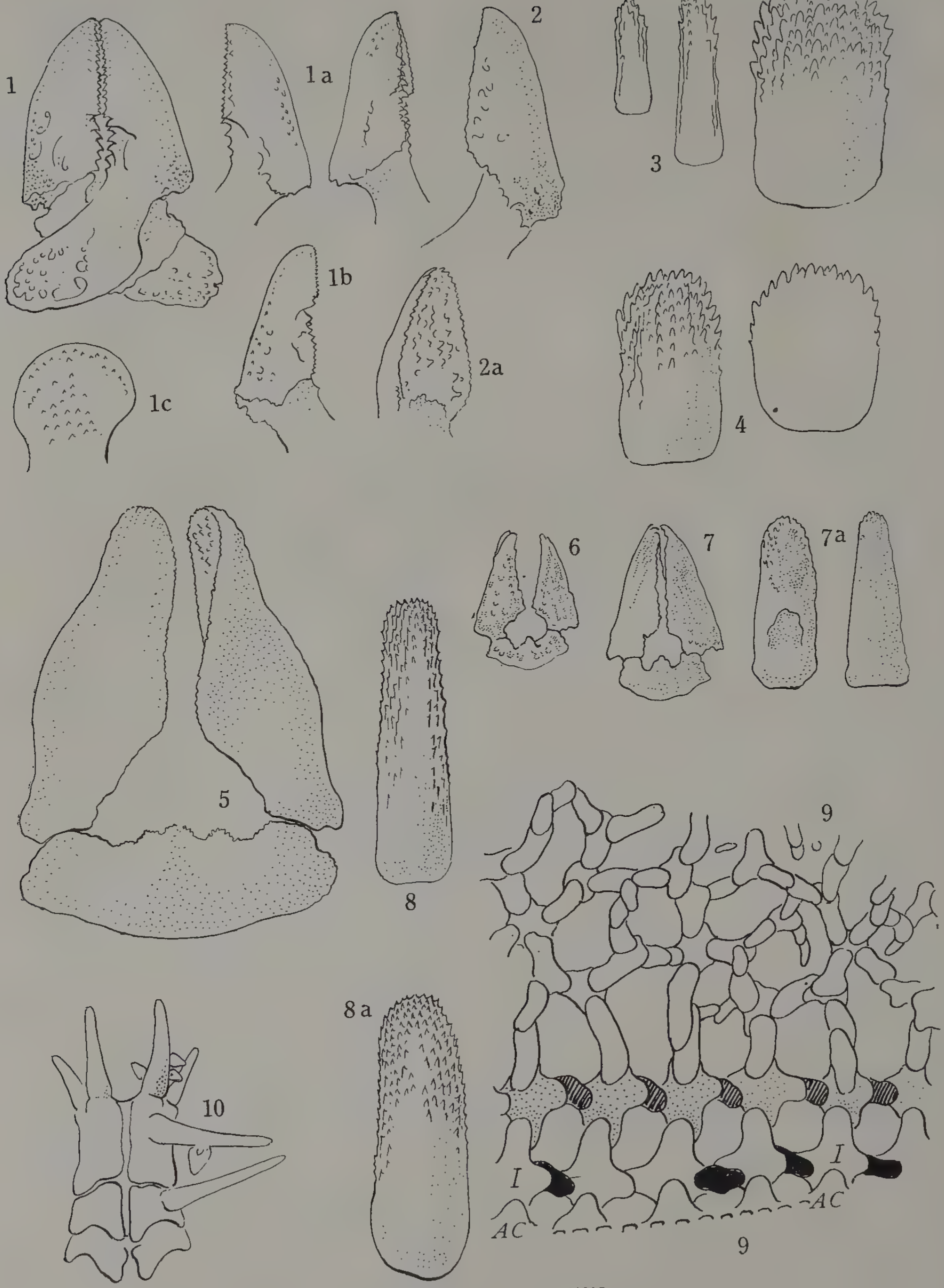
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LEPTASTERIAS OCHOTENSIS

EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 12

All figures *Leptasterias ochotensis*

FIGURE 1. Abactinal crossed pedicellaria, 0.235 mm., ×200. Specimen No. 1354, Mus. Acad. Sci., U. R. S. S.; coll. Middendorf.

1*a*. Two profile views of jaws.

1*b*. Same.

1*c*. Inside of end of jaw, ×200. 1*a* to 1*c*, specimen figured on Plate 27.

2. Crossed pedicellaria from an adambulacral spine, profile view.

2*a*. Inside of end of jaw (compare with 1*c*), ×200.

3. Three abactinal spinelets, ×50.

4. Two abactinal spinelets, that on right from carinal series, ×50.

5. An axillary straight pedicellaria, 0.7 mm. long, ×100.

6. A small abactinal straight pedicellariae, ×100.

7, 7*a*. Straight pedicellaria of adambulacral spine; a profile view, and inside and back of two different jaws, ×100.

8, 8*a*. Two inferomarginal spines, × only 38.

9. Plan of skeleton of middle of ray from actinal plates (*AC*) nearly to carinals; superomarginal plates stippled, secondary superomarginals cross-lined, secondary inferomarginal solid black, ×5. No. 1354, Mus. Acad. Sci. U. R. S. S.; coll. Middendorf.

10. Mouth and first two pairs of adambulacral plates, ×10.

PLATE 13

Leptasterias (*Nesasterias*) *stolacantha*

FIGURE 1. Projection of skeleton of base of ray, the small circles in the intervals indicating papulae; base of ray on left; ×8. *CAR–C*, carinal series; *D*, dorsolateral; *S*, superomarginal; *I*, inferomarginal; *A*, two series of actinals; *AD*, adambulacrals; *g*, point where gonad is attached.

2, 2*a*. Abactinal spinelet, showing the sheath and its crown of small pedicellariae, ×10.

2*b*. Marginal spinelets, ×10.

2*c*. Outer (left) and inner adambulacral spinelets, ×10.

3. Adambulacral spinelet, 1.5 mm., ×30.

3*a*. Marginal spinelet, ×30.

3*b*. Station 3319, marginal spinelet, ×30.

4. Mouth, angle; *g*, genital papilla; ×10.

5. Abactinal crossed pedicellaria, 0.135 mm., station 3321, ×200.

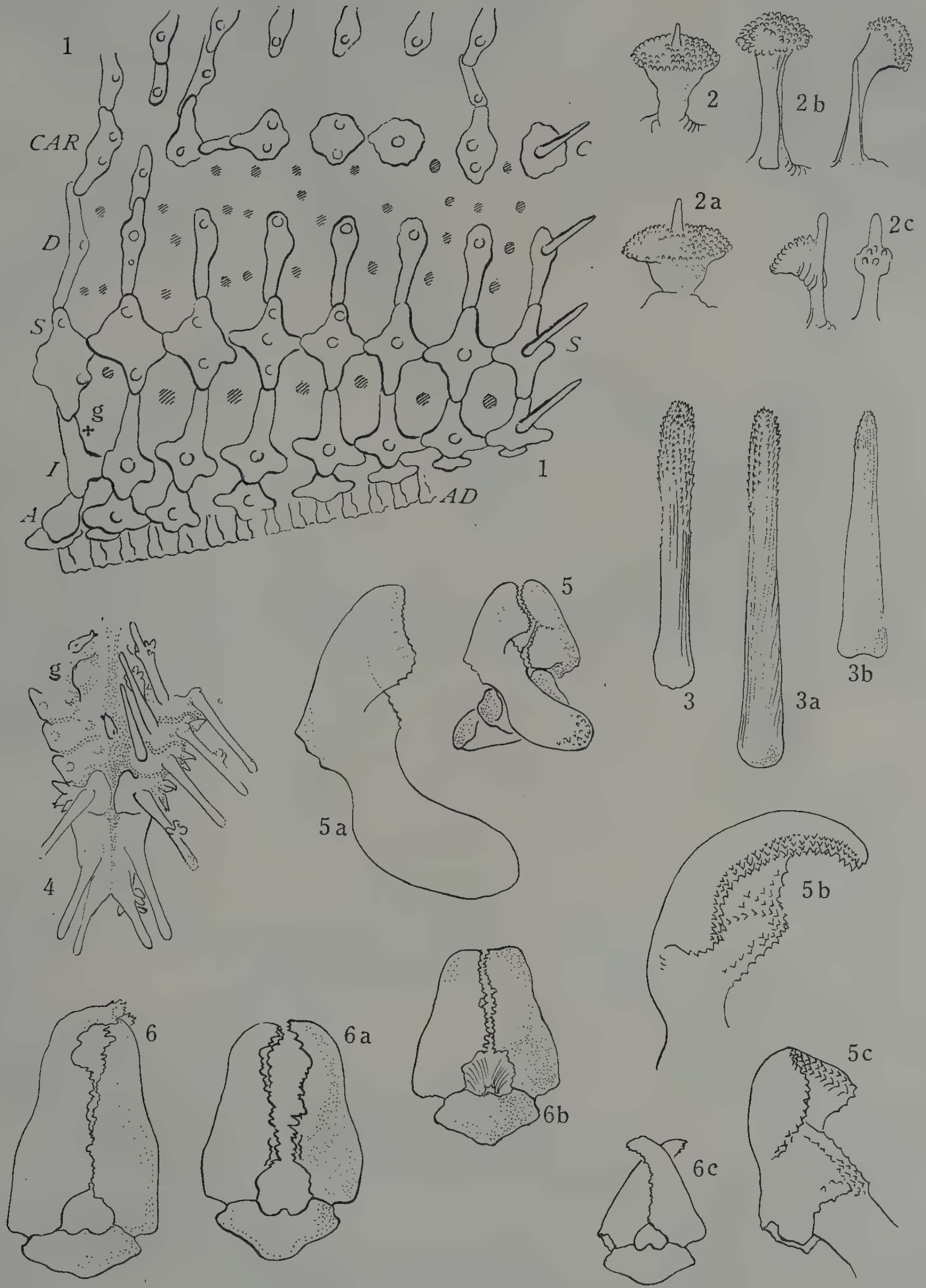
5*a*. A jaw, ×400.

5*b*, 5*c*. Two views of adambulacral pedicellariae, station 3321, ×400.

6. An axillary straight pedicellaria from near genital papilla (see fig. 4), 0.43 mm., ×100.

6*a*, 6*b*. Abactinal straight pedicellariae, 0.36 and 0.29 mm., ×100.

6*c*. From adambulacral spinelet, 0.23 mm., ×100.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LEPTASTERIAS (NESASTERIAS) STOLACANTHA

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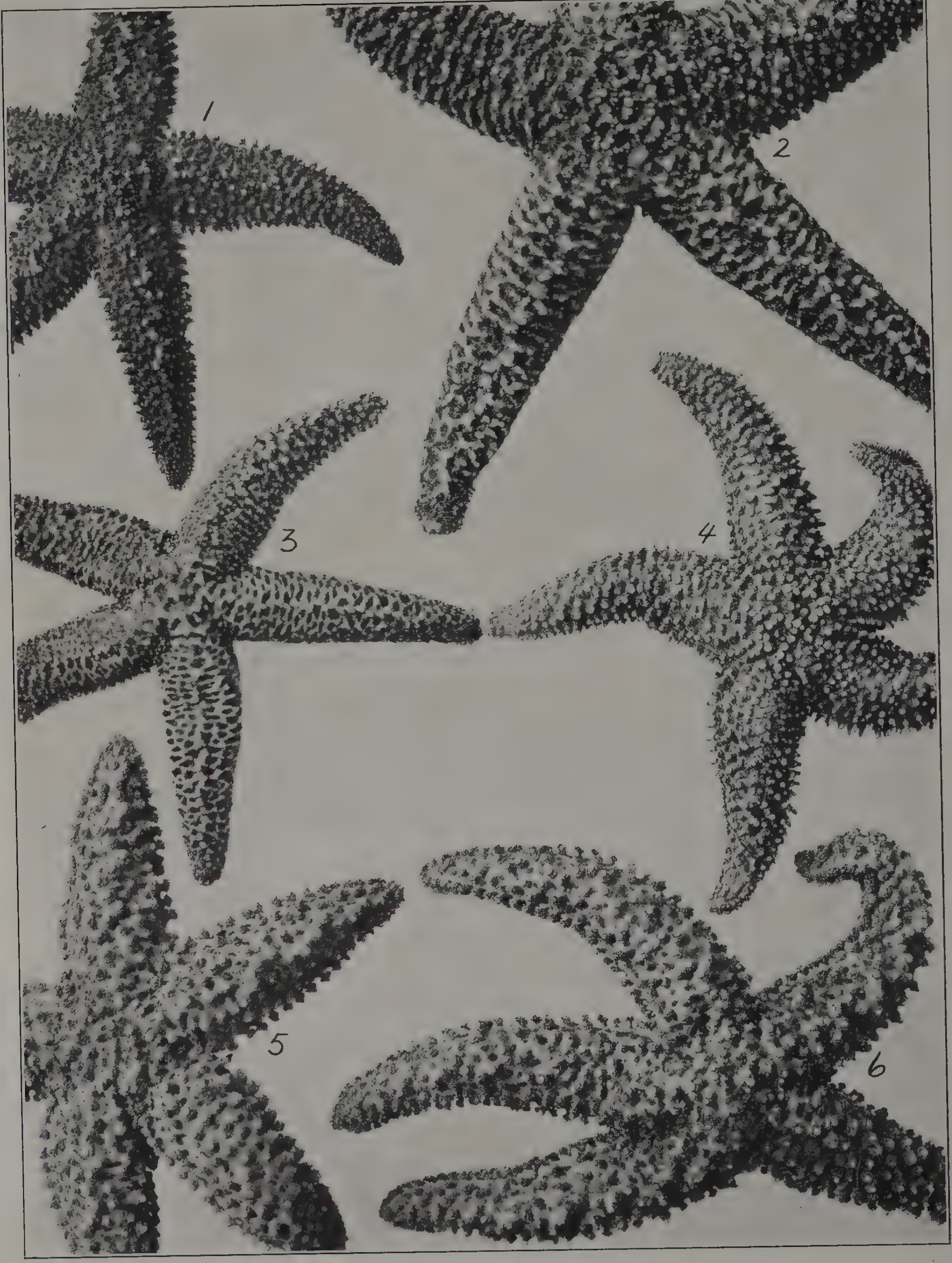


Leptasterias arctica

For explanation of plate see page facing

PLATE 14

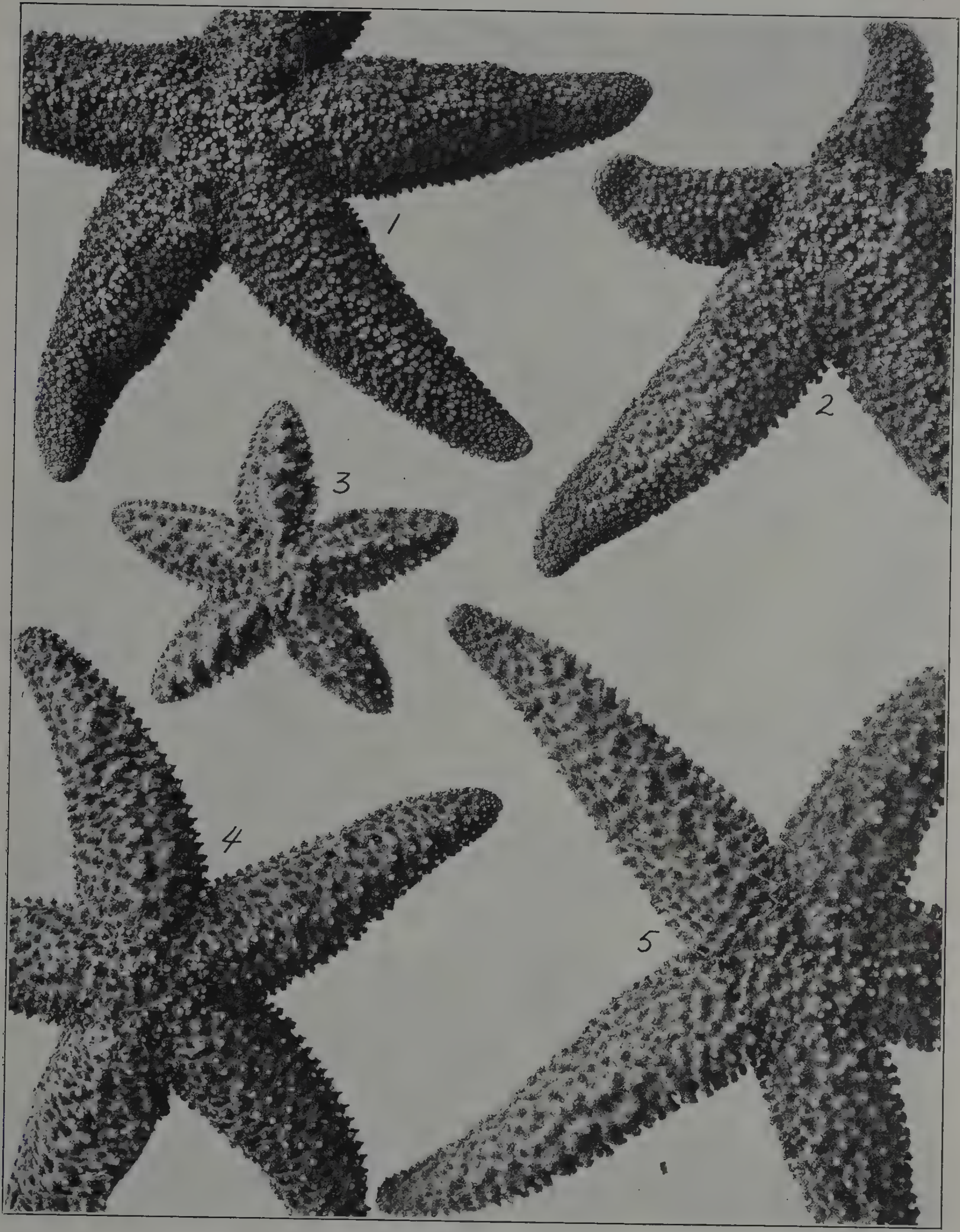
Leptasterias arctica

FIGURE 1. Forma *arctica*, cotype, No. 7625.
2. Same, probably station 3514, 59° 22′ N., 168° 21′ W.
3. Same, locality lost, cleaned to show skeleton.
4. Same, Nikolski, Bering Islands.
5. Forma *beringensis*, station 3303.
6. Same, station 3302.

PLATE 15

Leptasterias arctica

FIGURE 1. Forma *arctica*, station 3559, not typical.
2. Forma *beringensis*, intermediate with f. *arctica*, station 3510.
3. Forma *beringensis*, station 3293.
4. Same, station 3294.
5. Same (type of forma), station 3277.



LEPTASTERIAS ARCTICA

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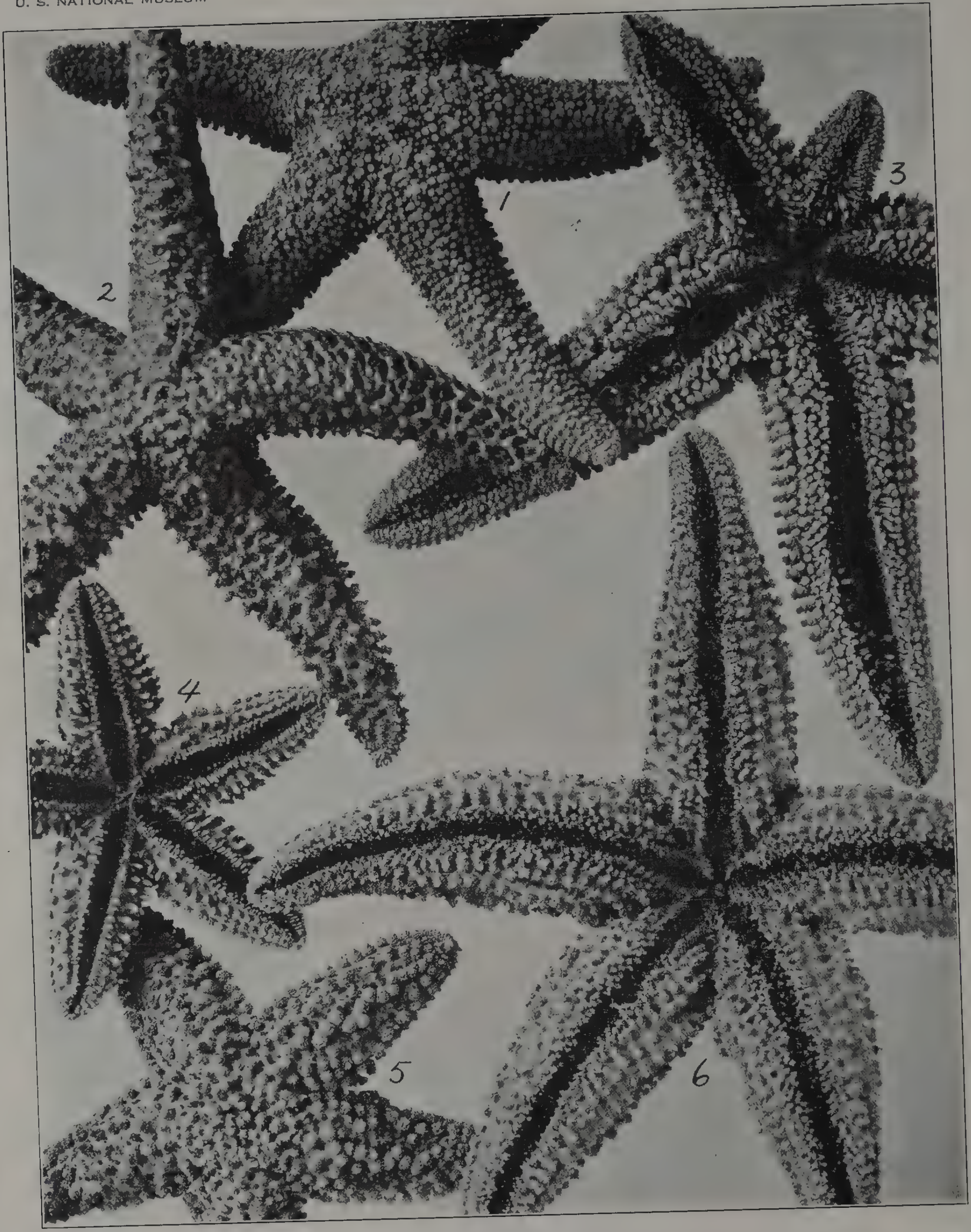


LEPTASTERIAS ARCTICA

FOR EXPLANATION OF PLATE SEE PAGE FACING.

Plate 16

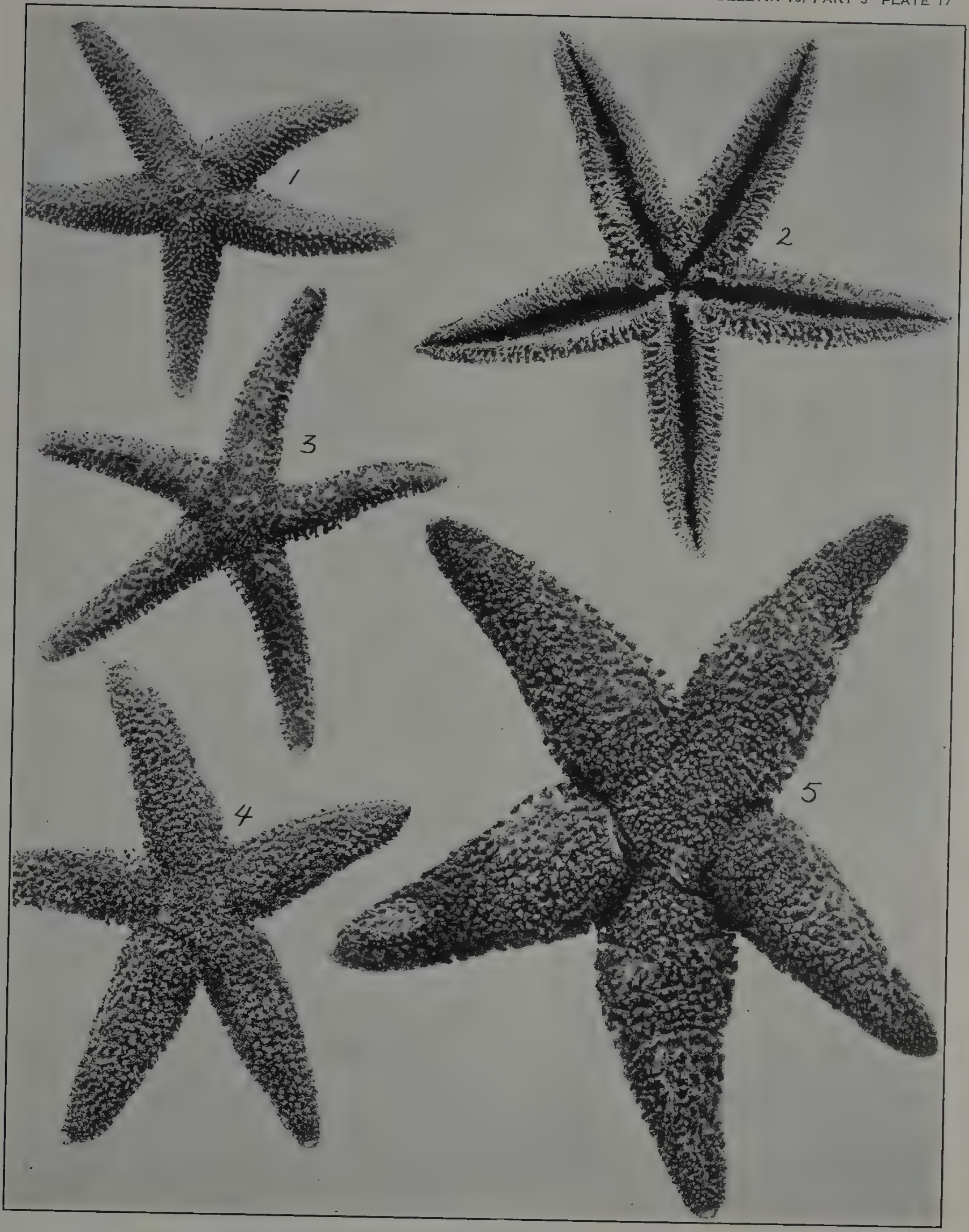
Leptasterias arctica, enlarged

Figure 1. Forma *arctica*, 60° 22′ N., 168° 45′ W.
2. Forma *beringensis*, station 3294.
3. Same, station 3504.
4. Same, station 3293.
5. Same, station 3294.
6. Same, station 3510.

PLATE 17

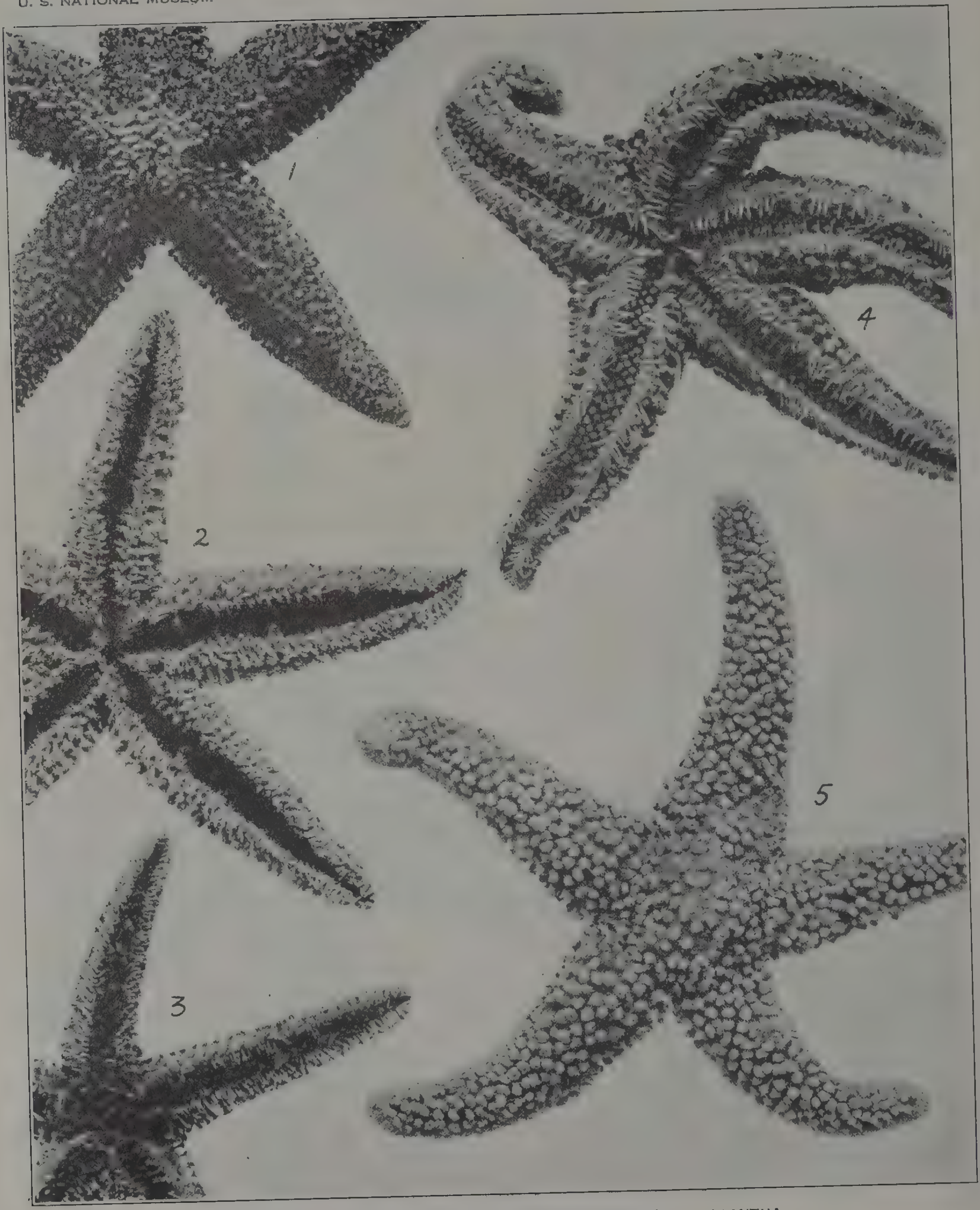
Leptasterias hylodes, ×1⅔.

FIGURE 1. Station 2856.
2, 3, 4. Station 2847.
5. Type, station 2851.



Leptasterias hylodes

For explanation of plate see page facing.



1-3. Leptasterias hylodes. 4, 5. L. (Nesasterias) stolacantha

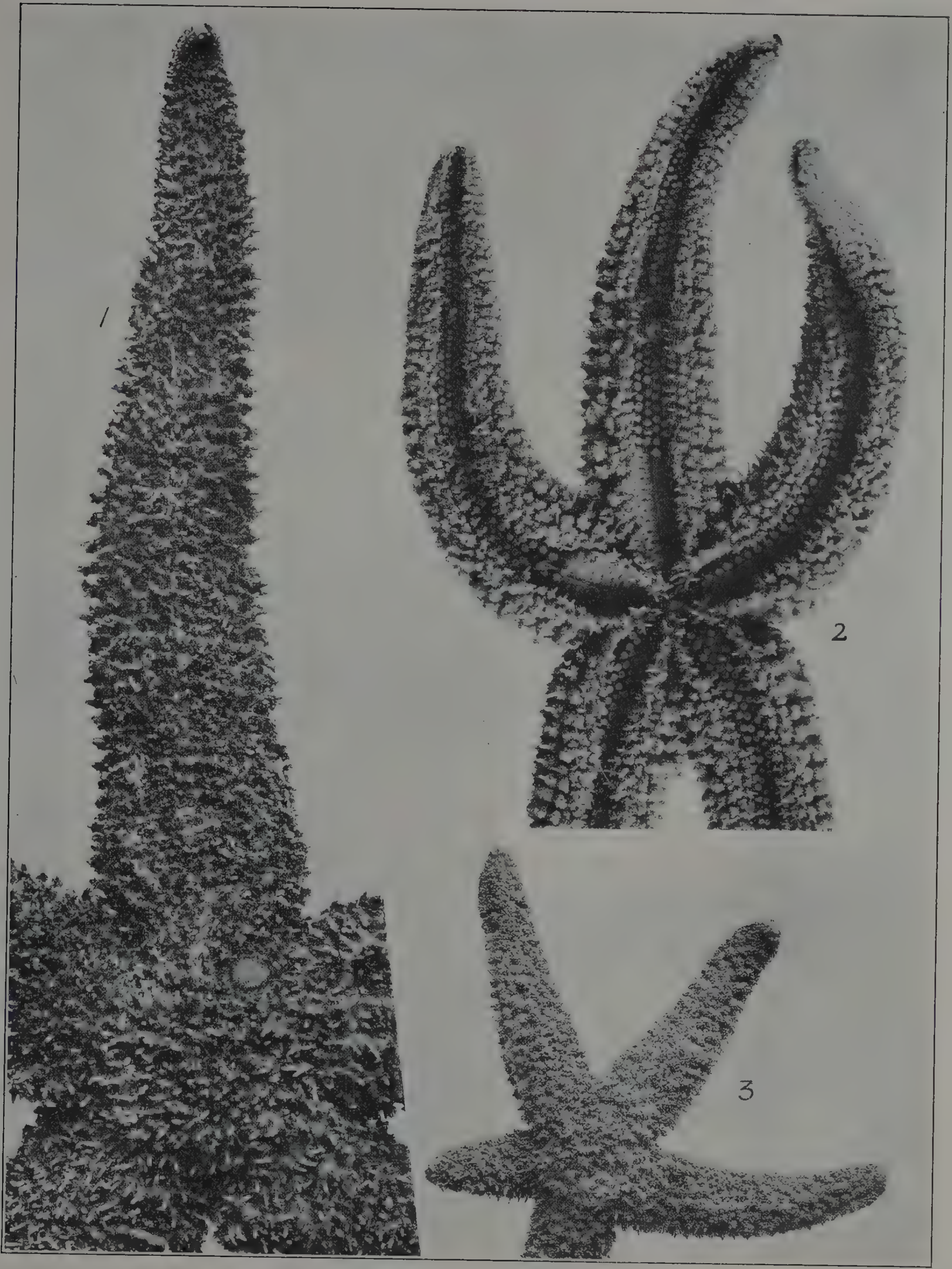
For explanation of plate see page facing.

PLATE 18

FIGURES 1, 2, 3. *Leptasterias hylodes*, station 2851, ×2⅕.
4. *Leptasterias (Nesasterias) stolacantha*, station 3321, ×2⅕.
5. *Leptasterias (Nesasterias) stolacantha*, type, station 3322, ×2⅕.

PLATE 19

FIGURE 1. *Leptasterias hyperborea*, Spitzbergen, No. 207, Riksmuseum, Stockholm, ×2.
2. *Leptasterias orientalis*, Okhotsk Sea, 57° 36′ N., 140° 34′ E., 106 meters, mud, ×2.
3. *Leptasterias orientalis*, station 5024, ×2.



1. LEPTASTERIAS HYPERBOREA. 2, 3. L. ORIENTALIS

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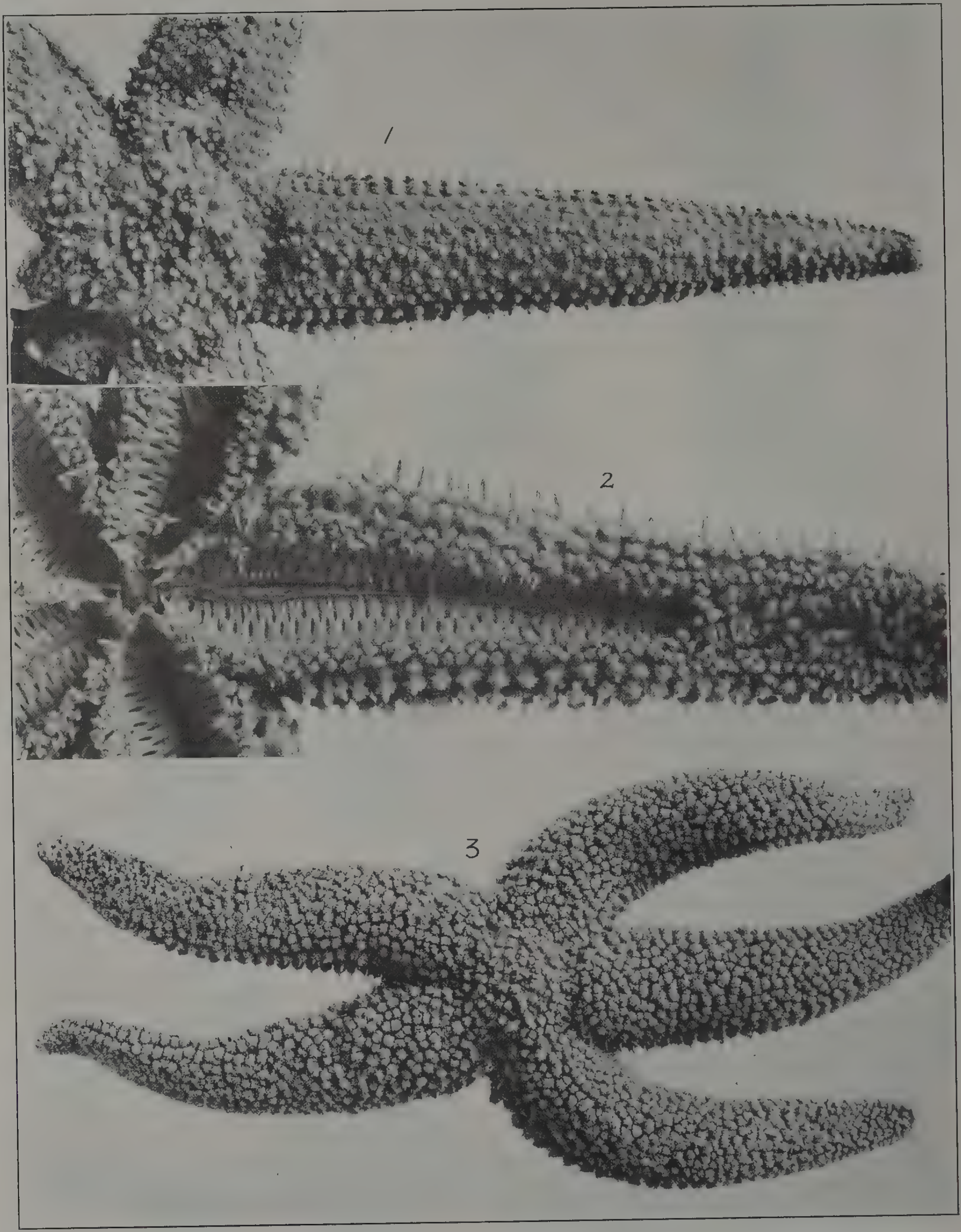


1, 2. LEPTASTERIAS FISHERI. 3. L. ORIENTALIS

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 20

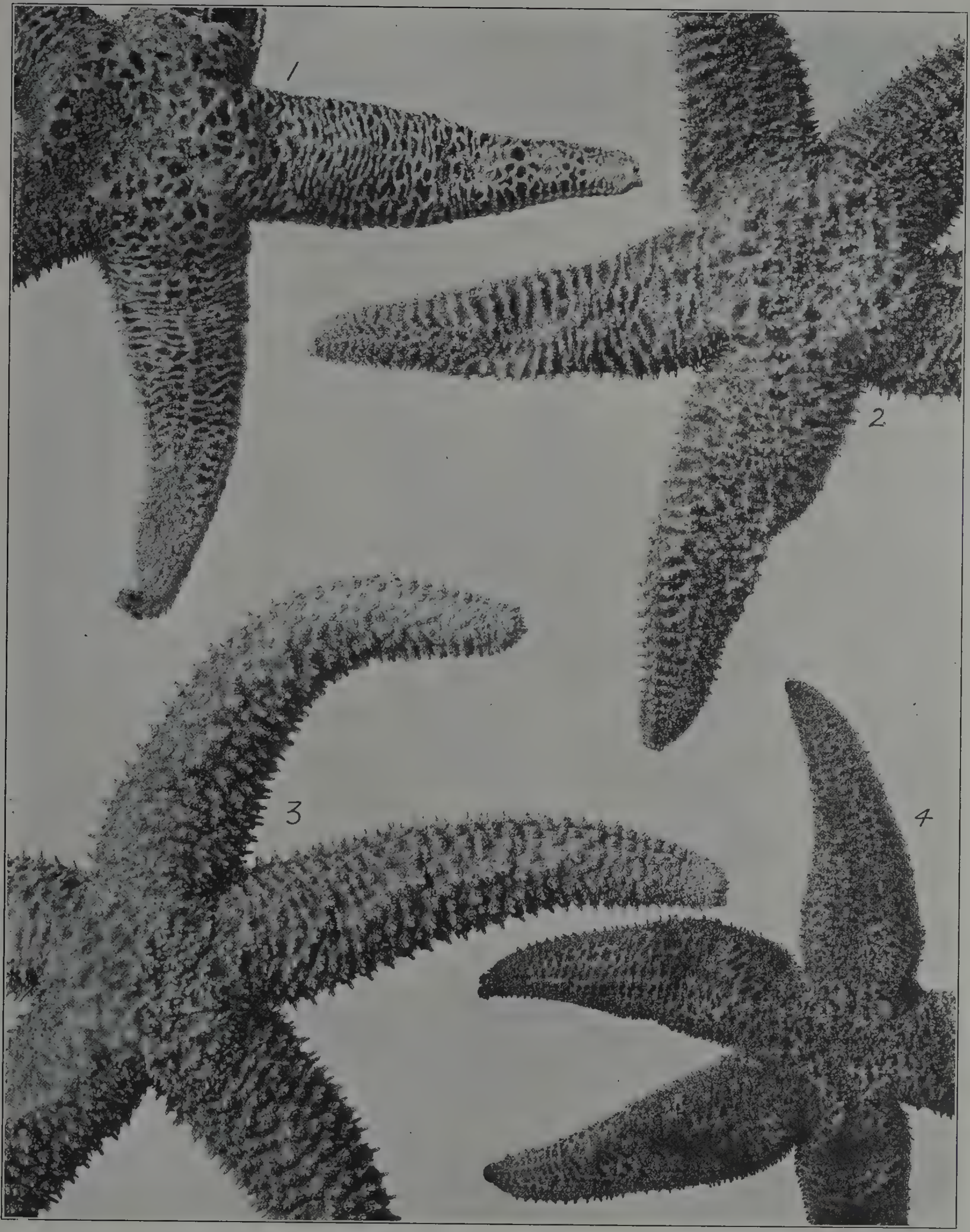
FIGURE 1. *Leptasterias fisheri*; Okhotsk Sea, 50° 03′ N., 144° 08′ E., 110 meters, mud, ×1½.

2. *Leptasterias fisheri*, actinal view of Figure 1, ×2½.
3. *Leptasterias orientalis*, Okhotsk Sea, 57° 36′ N., 140° 34′ E., 106 meters, mud. Abactinal view of Plate 19, Figure 2, ×1½.

PLATE 21

Leptasterias groenlandica, ×2

FIGURES 1, 2. Forma *cribraria*, station 3252.
3. Forma *groenlandica*, station 3520.
4. Forma *cribraria*, No. 1349, Arctic Ocean.



LEPTASTERIAS GROENLANDICA

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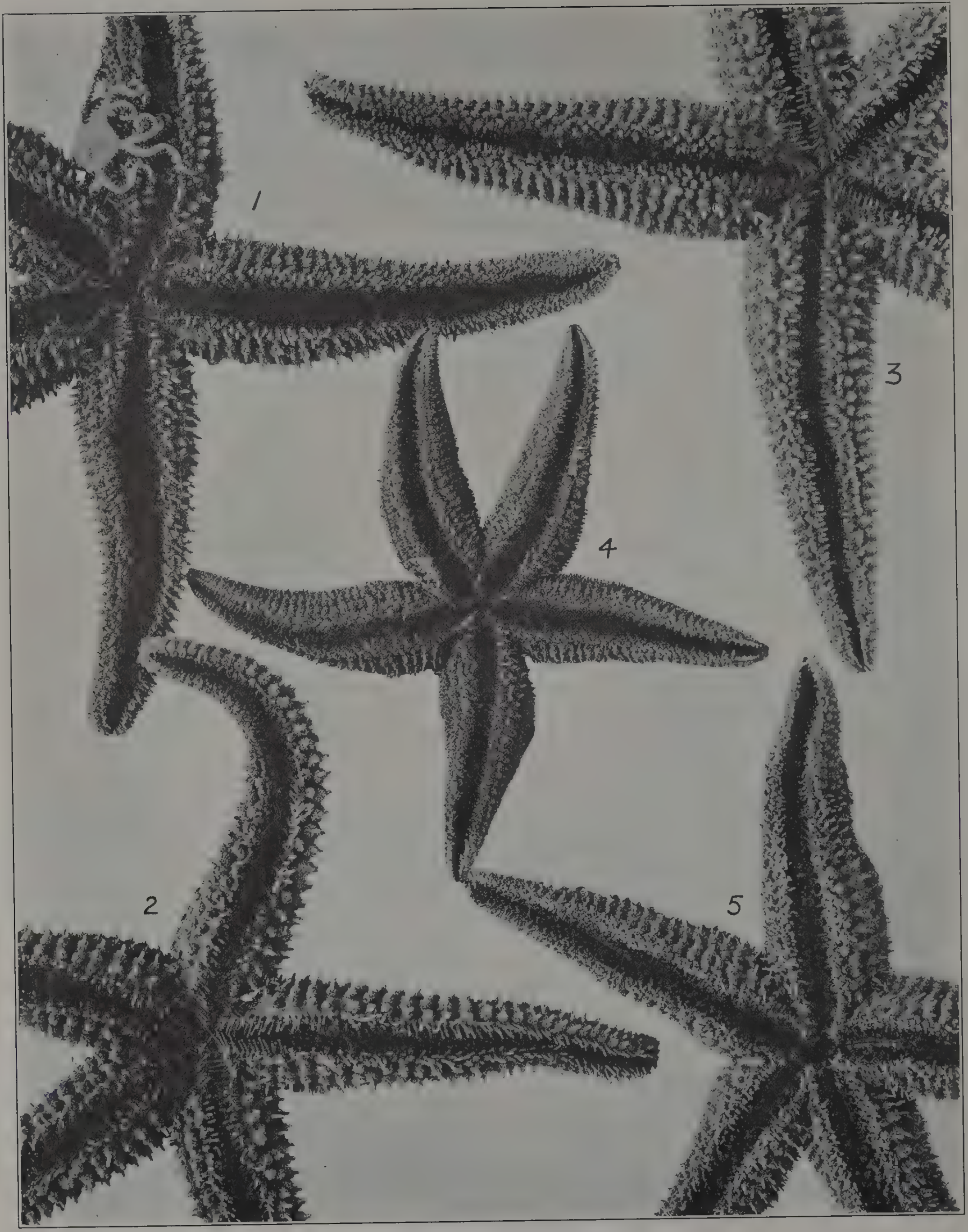

LEPTASTERIAS GROENLANDICA

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PLATE 22

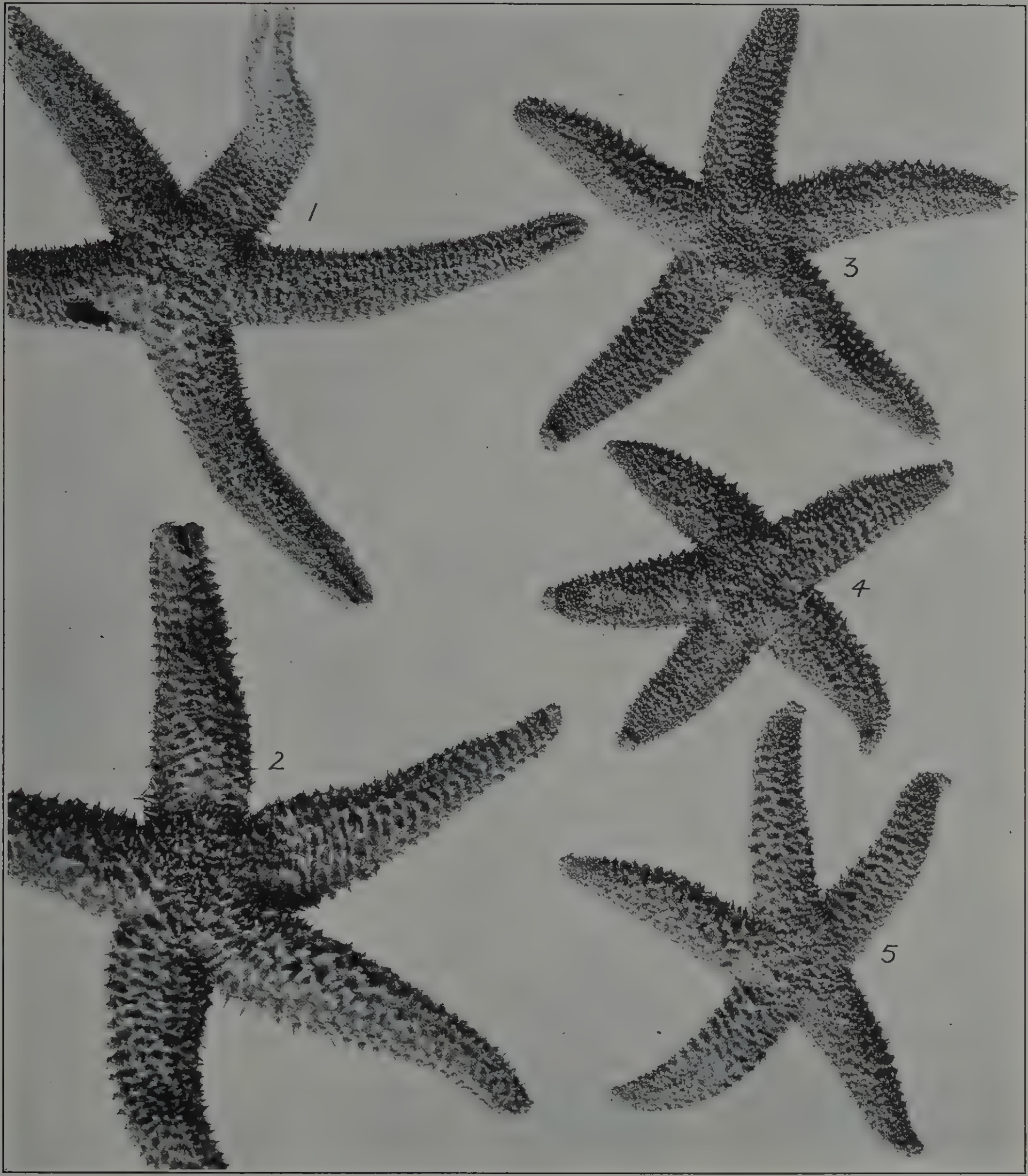
Leptasterias groenlandica, ×1⅗

FIGURE 1. Forma *groenlandica,* station 3506.
2. Same, station 3520.
3. Forma *cribraria,* station 3522.
4. Same, No. 1349, Arctic Ocean.
5. Same, station 3252.

PLATE 23

Leptasterias groenlandica forma *groenlandica*, ×2

FIGURE 1. From north of Asia, Stanford collection.
2. Station 3531.
3, 4, 5. Station 3252.



LEPTASTERIAS GROENLANDICA

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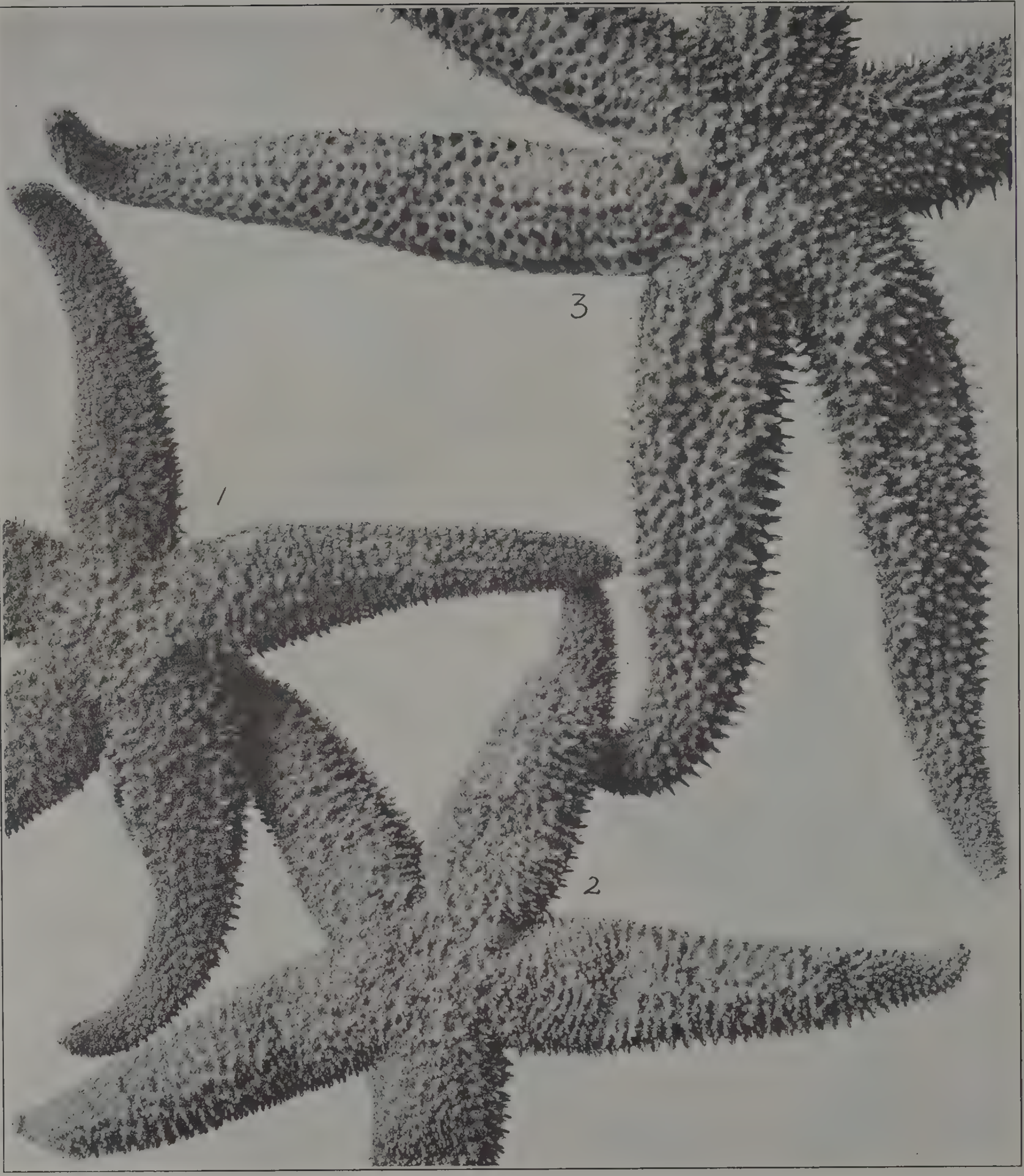

1, 2. LEPTASTERIAS GROENLANDICA. 3. L. COEI TRUCULENTA

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Plate 24

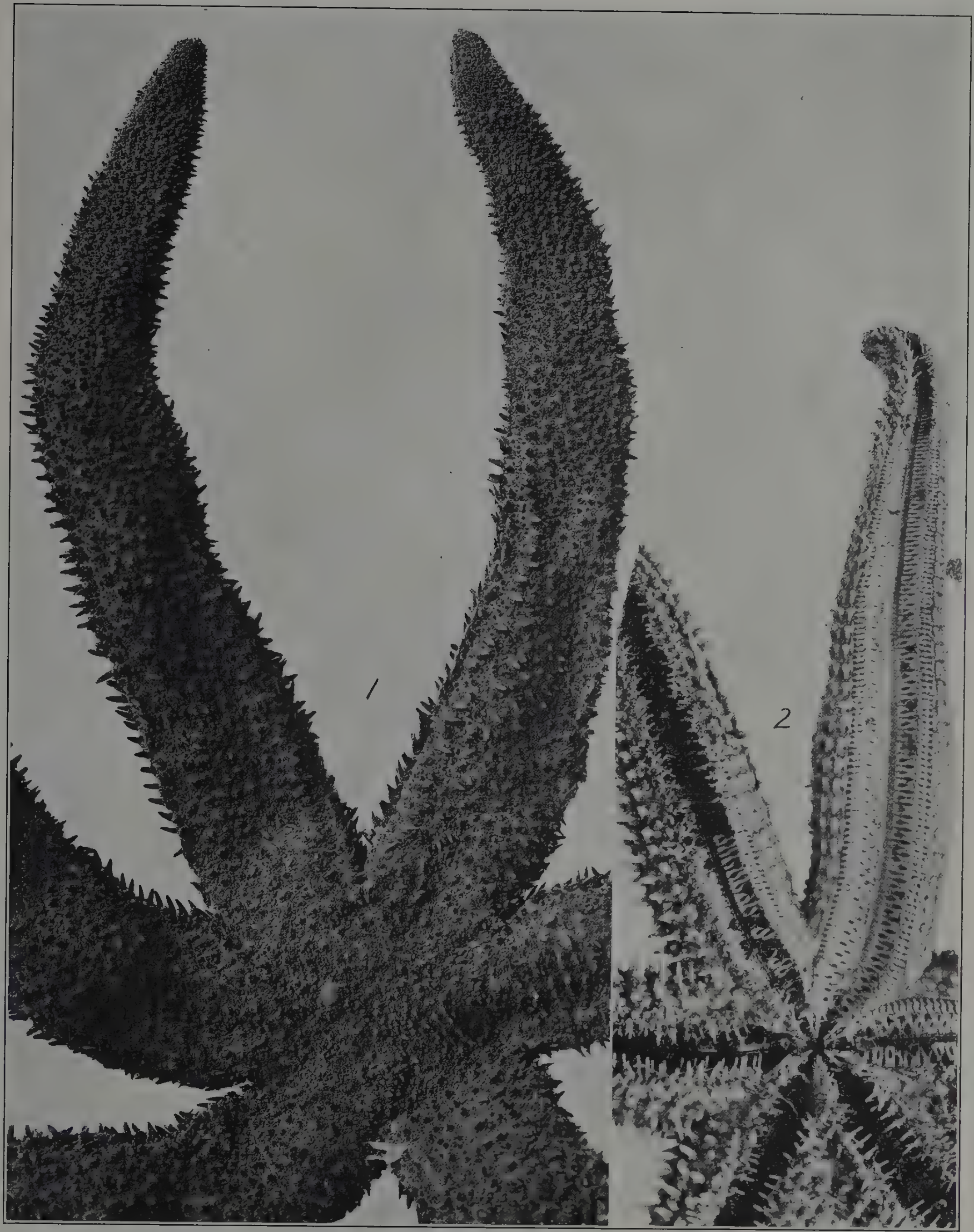
Figure 1. *Leptasterias groenlandica* forma *groenlandica*, station 3506, ×1⅗. Resembles *L. hyperborea.*

2. *Leptasterias groenlandica* forma *cribraria*, station 3522, ×1⅗.

3. *Leptasterias coei truculenta*, station 4779, ×1⅗.

PLATE 25

FIGURE 1. *Leptasterias coei truculenta*, type, Captains Bay, Unalaska, ×9/10.
2. Same, station 4779.



Leptasterias coei truculenta

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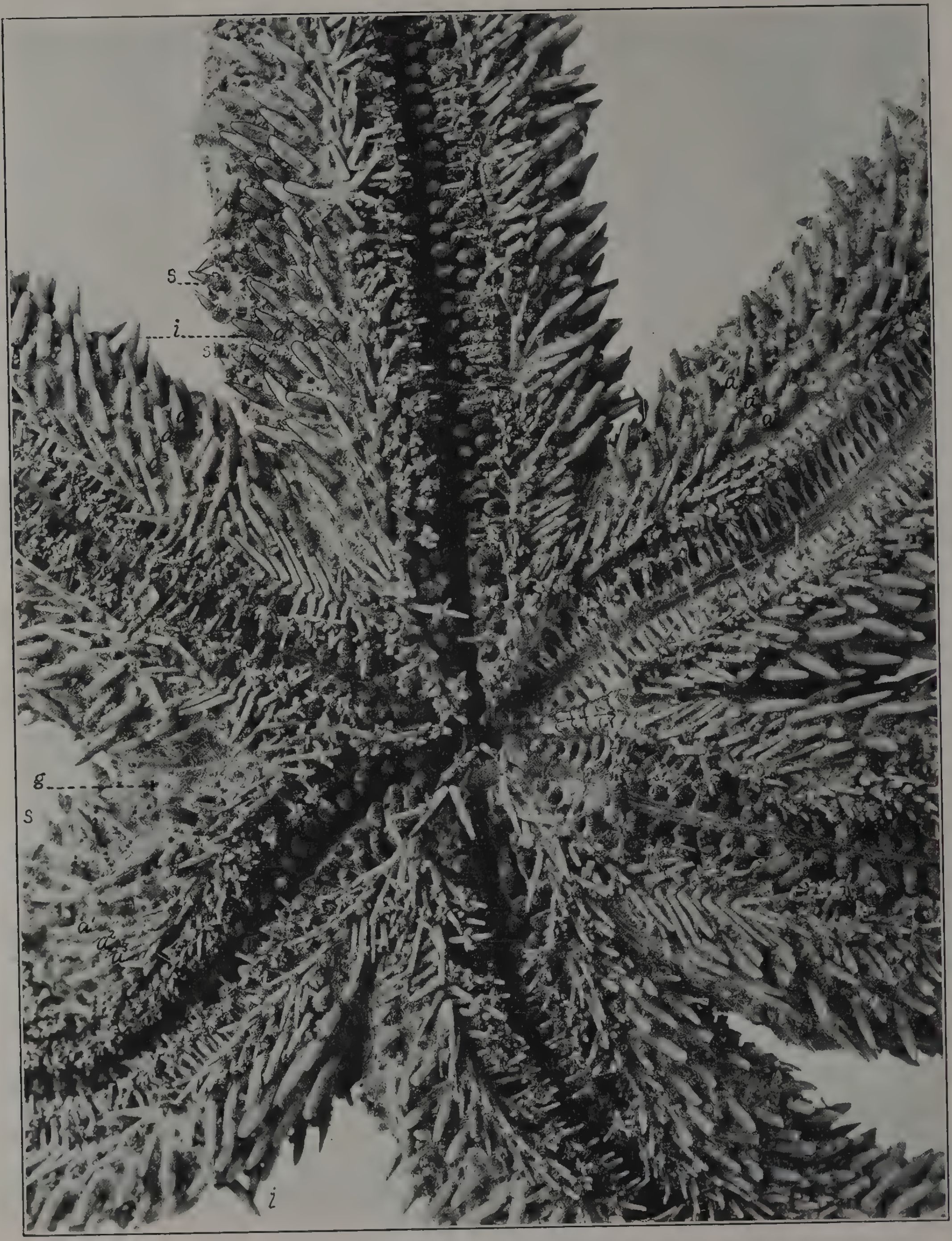
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Leptasterias coei truculenta

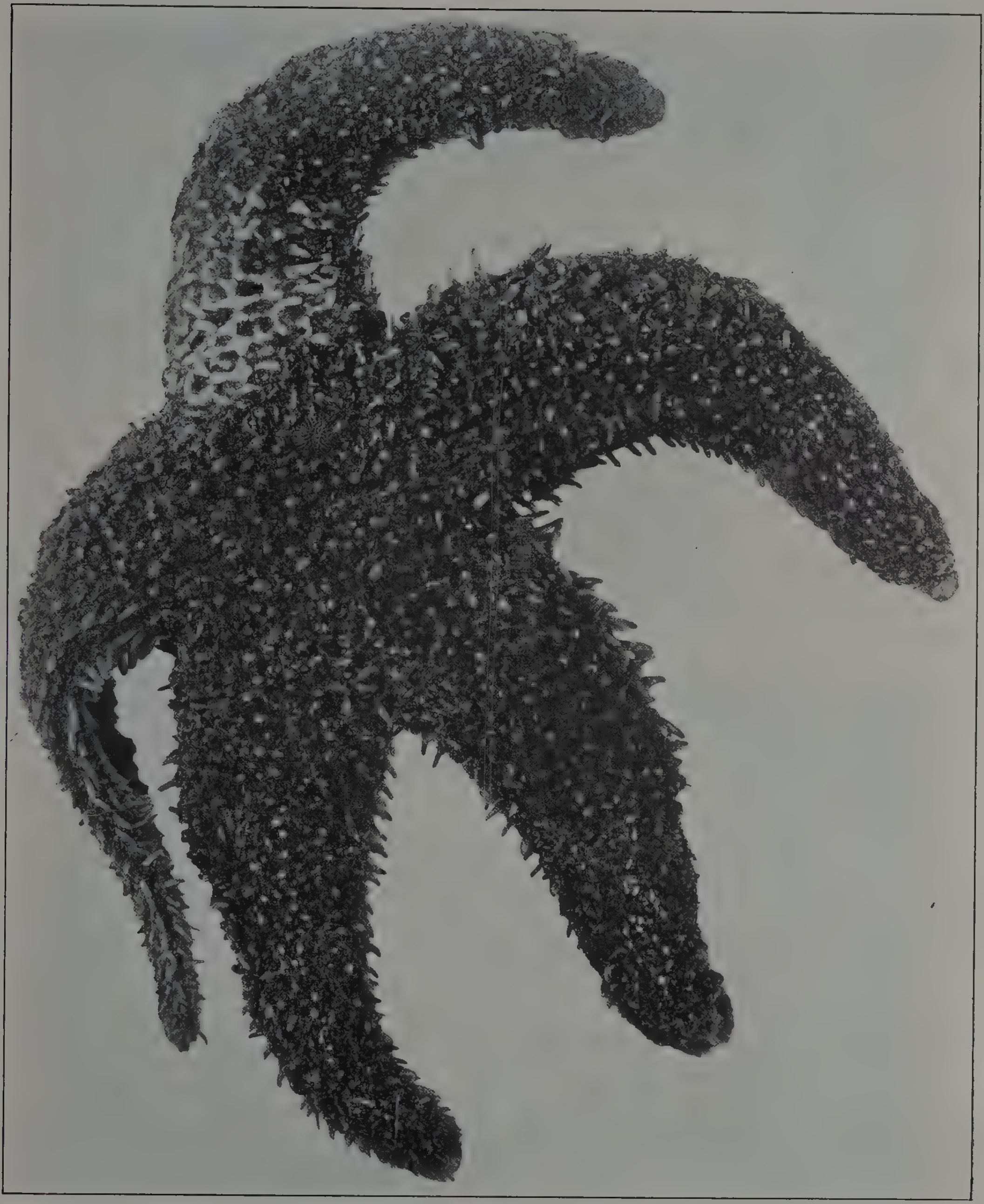
For explanation of plate see page facing.

Plate 26

Leptasterias coei truculenta, type, ×2. a^1, a^2, a^3, three series of actinal spines; *i*, inferomarginals; *s*, superomarginals; *g*, aperture of gonoduct.

Plate 27

Leptasterias ochotensis, abactinal view of specimen from Zoological Museum, Copenhagen; × a little over 3.



LEPTASTERIAS OCHOTENSIS

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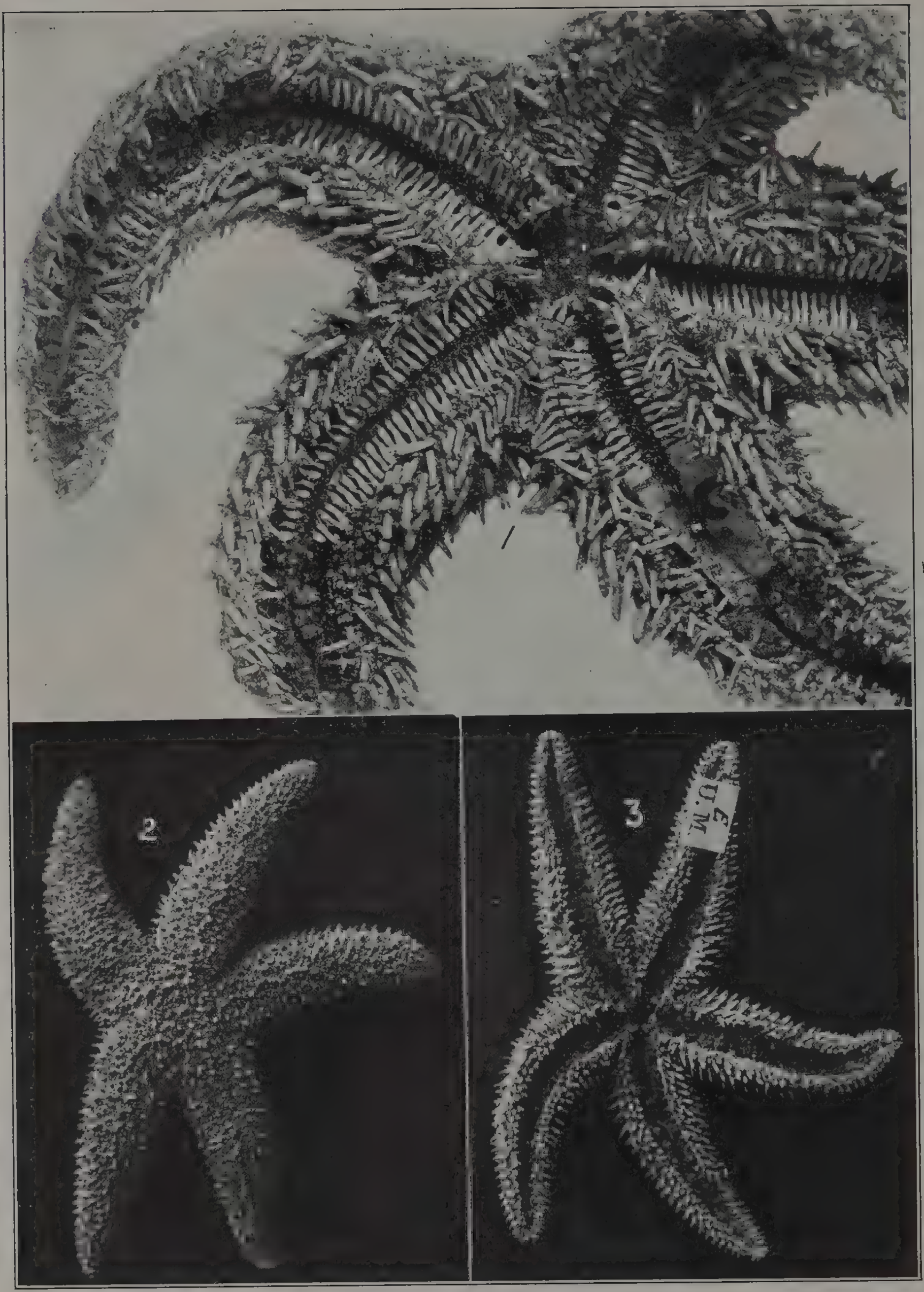


LEPTASTERIAS OCHOTENSIS

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 28

Leptasterias ochotensis

FIGURE 1. Actinal aspect of Plate 27.

2, 3. Two views of Brandt's var. *macrobrachia,* Zoological Museum, Copenhagen, ×1.3; Dr. Th. Mortensen.

PLATE 29

FIGURE 1. *Leptasterias coei truculenta*, station 4779; abactinal pedicellariae, 0.3 mm., ×100.

1*a*. From adambulacral spine, 0.27 mm., ×100.

1*b*. From adambulacral spine, ×200.

1*c*. Abactinal, ×200.

1*d*. From adambulacral spine of type, ×200.

1*e*. Type, abactinal, ×200.

2. *Leptasterias coei truculenta*, two abactinal spinelets of type, ×25.

2*a*. Same, station 4779, abactinal spinelets, ×25.

2*b*. Type, actinal spine, ×25.

3. *Leptasterias coei*. Type of *Orthasterias merriami* Verrill, abactinal pedicellariae, 0.3 mm, ×100.

3*a*. Same specimen; from adambulacral spinelet, ×200.

4. *Leptasterias coei truculenta*, station 4779; abactinal straight pedicellariae, ×50.

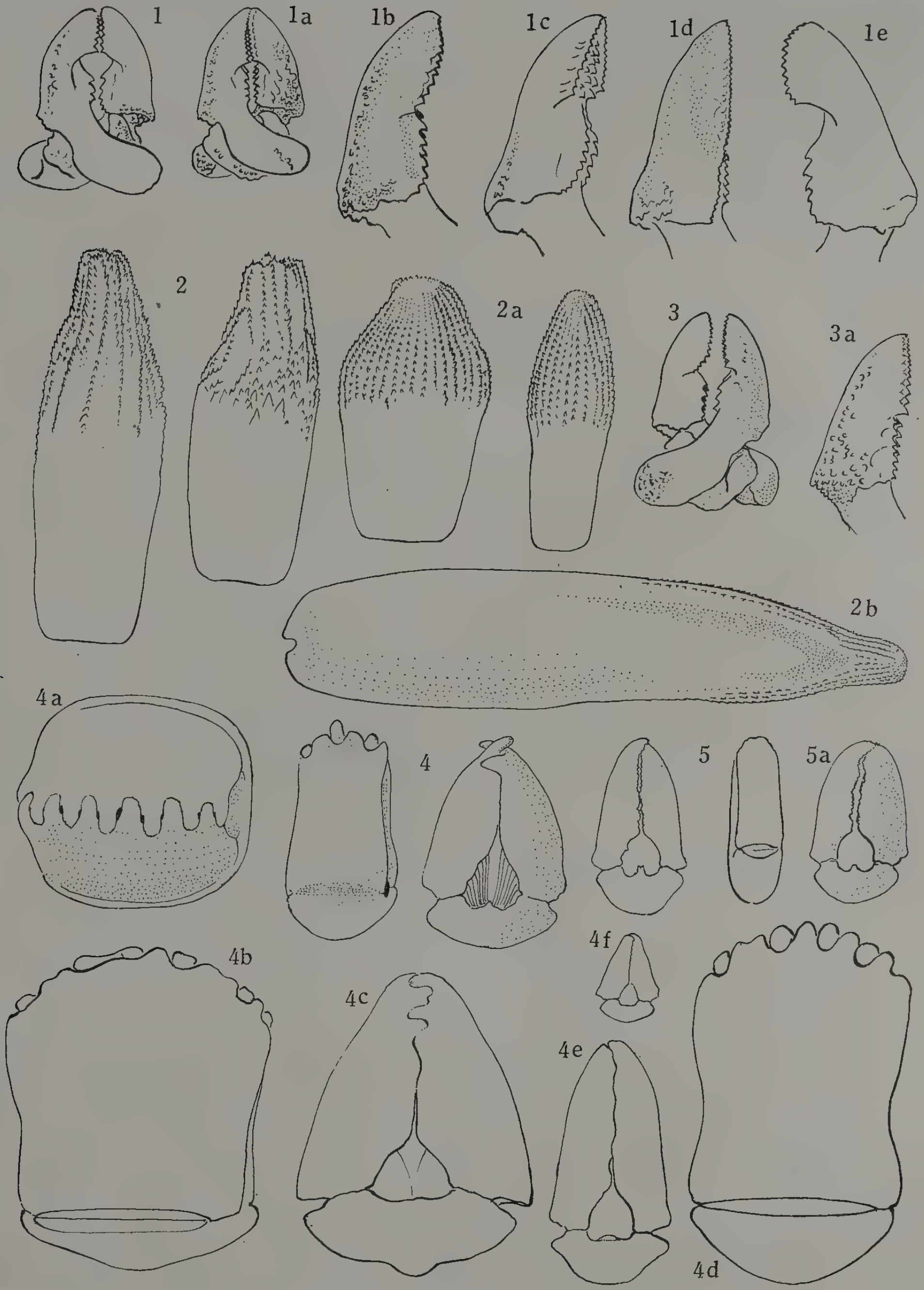
4*a*, 4*b*, 4*c*. Same, station 4779; three views of intermarginal pedicellariae, the largest 1 mm. high, ×50.

4*d*. Same, type; intermarginal, 1.2 mm., ×50.

4*e*. Same, type; from adambulacral spine; ×50.

4*f*. Same, type; from border of adambulacral furrow, 0.29 mm., ×50.

5, 5*a*. *Leptasterias coei*. Type of *Orthasterias merriami* Verrill; three views of lateral straight pedicellariae, ×50.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1-4. LEPTASTERIAS COEI TRUCULENTA. 5. L. COEI

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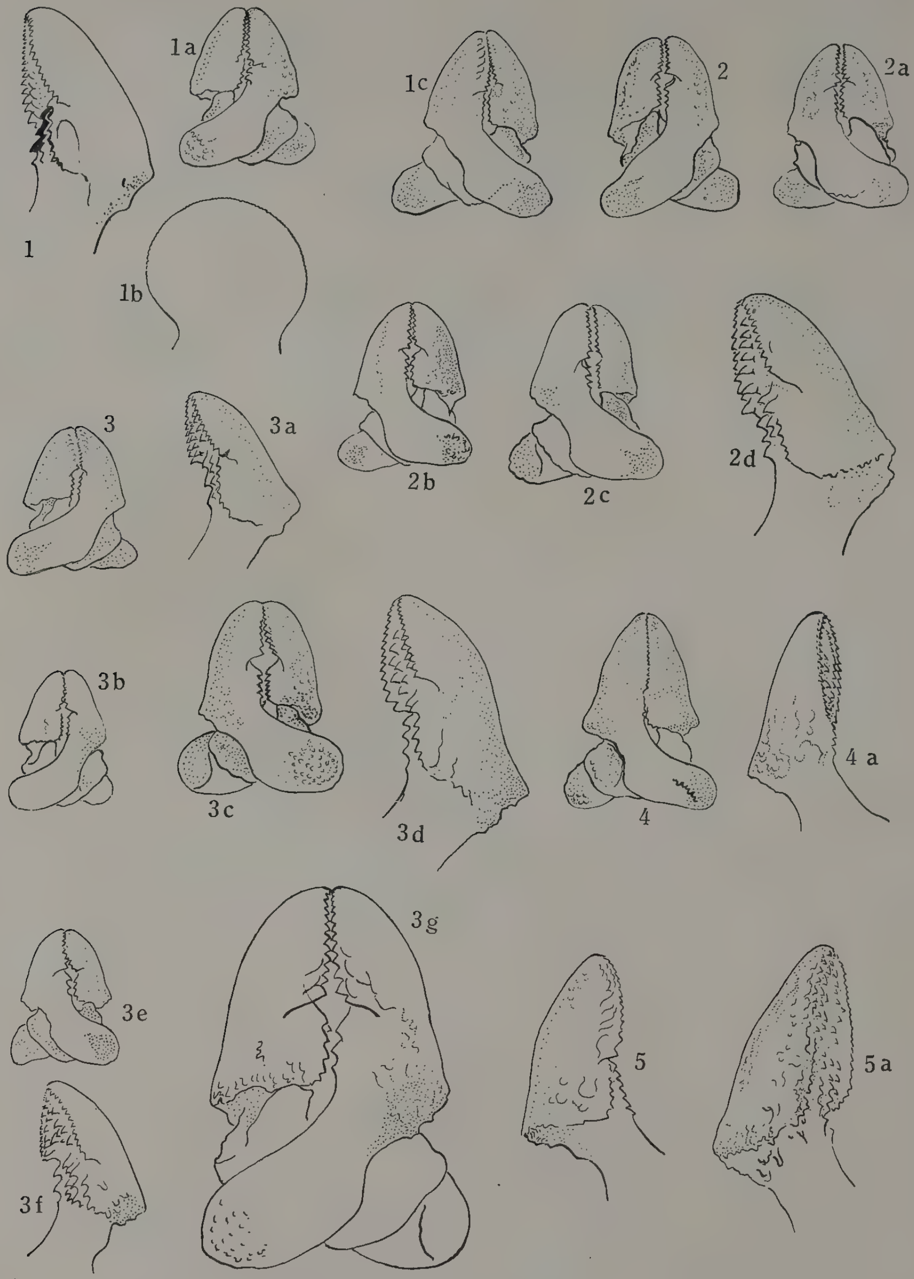
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1. LEPTASTERIAS POLARIS. 2. L. POLARIS BOREALIS. 3–5. L. POLARIS ACERVATA

FOR EXPLANATION OF PLATE SEE PAGE FACING.

Plate 30

All pedicellariae abactinal unless specified

Figure 1. *Leptasterias polaris,* Davis Strait, No. 38834, U. S. Nat. Mus.; one jaw of a crossed pedicellaria from side, ×200.

1*a*. Same specimen, length 0.26 mm., ×100.

1*b*. Same specimen, end of jaw, ×200.

1*c*. Same, Disco Island, Greenland, No. 15815, U. S. Nat. Mus., length 0.29 mm., ×100.

2. *Leptasterias polaris borealis,* West Bank, from a very large specimen, length 0.27 mm.

2*a*. Same, Caribou Island, Labrador, No. 1307, M. C. Z.; specimen with spaced, rather long spines, 0.26 mm., ×100.

2*b*. Same, Newfoundland Banks, 0.26 mm., ×100.

2*c*. Same, Gaspé, Quebec, M. C. Z., 1308, 0.27 mm.

2*d*. Same specimen, a jaw, ×200.

3. *Leptasterias polaris acervata* forma *acervata,* No. 6111, U. S. Nat. Mus., Cape Lisburne, Alaska, 0.225 mm., ×100.

3*a*. Same specimen (with small clusters of spines resembling pl. 37, fig. 2); a jaw, ×200.

3*b*. Same, off Indian Point, Bering Sea, No. 6086, U. S. Nat. Mus. (pl. 37, fig. 4) 0.225 mm., ×100.

3*c*. Same, station 3496; variety with very large bivalved straight pedicellariae, 0.32 mm., ×100.

3*d*. Same specimen, ×200.

3*e*. Same, station 3235 (pl. 37, fig. 2), 0.22 mm.

3*f*. Same specimen, ×200.

3*g*. Same, No. 39984, U. S. Nat. Mus., off St. George Island, Bering Sea, 0.30 mm., ×200.

4. Same, pedicellaria from an adambulacral spine, 0.31 mm., ×100. Station 3496, same specimen as Figures 5*a*, 5*b*.

4*a*. Indian Point, Bering Sea, same specimen as Figure 3*b;* pedicellaria from an adambulacral spine, 0.23 mm., ×200.

5. *Leptasterias polaris acervata* forma *polythela,* station 3518; pedicellaria from an adambulacral spine 0.30 mm., ×200.

5*a*. Same, station 3251; an adambulacral crossed pedicellaria, ×200.

PLATE 31

All pedicellariae are abactinal unless specified

FIGURE 1. *Leptasterias polaris acervata* forma *polythela,* No. 15817, U. S. Nat. Mus., Arctic Ocean north of Bering Strait, 0.25, ×200.

1*a*. Same, station 3518, specimen with well developed abactinal spines, 0.27 mm., ×200.

1*b*. Same, station 3251, very large specimen, 0.26 mm., ×200.

1*c*. Station 3439, 0.29 mm., ×200.

1*d*. Same specimen as 1*c*, end of jaw, ×200.

1*e*. Same, station 4795, off Kamchatka, 0.27 mm., ×200.

1*f*. Same specimen, ×100.

2. *Leptasterias polaris acervata* forma *aphelonota,* type, station 2850, 0.27 mm., ×200.

2*a*. Same, type; two pedicellariae showing different contours, ×100.

2*b*. Same, station 3214, ×100.

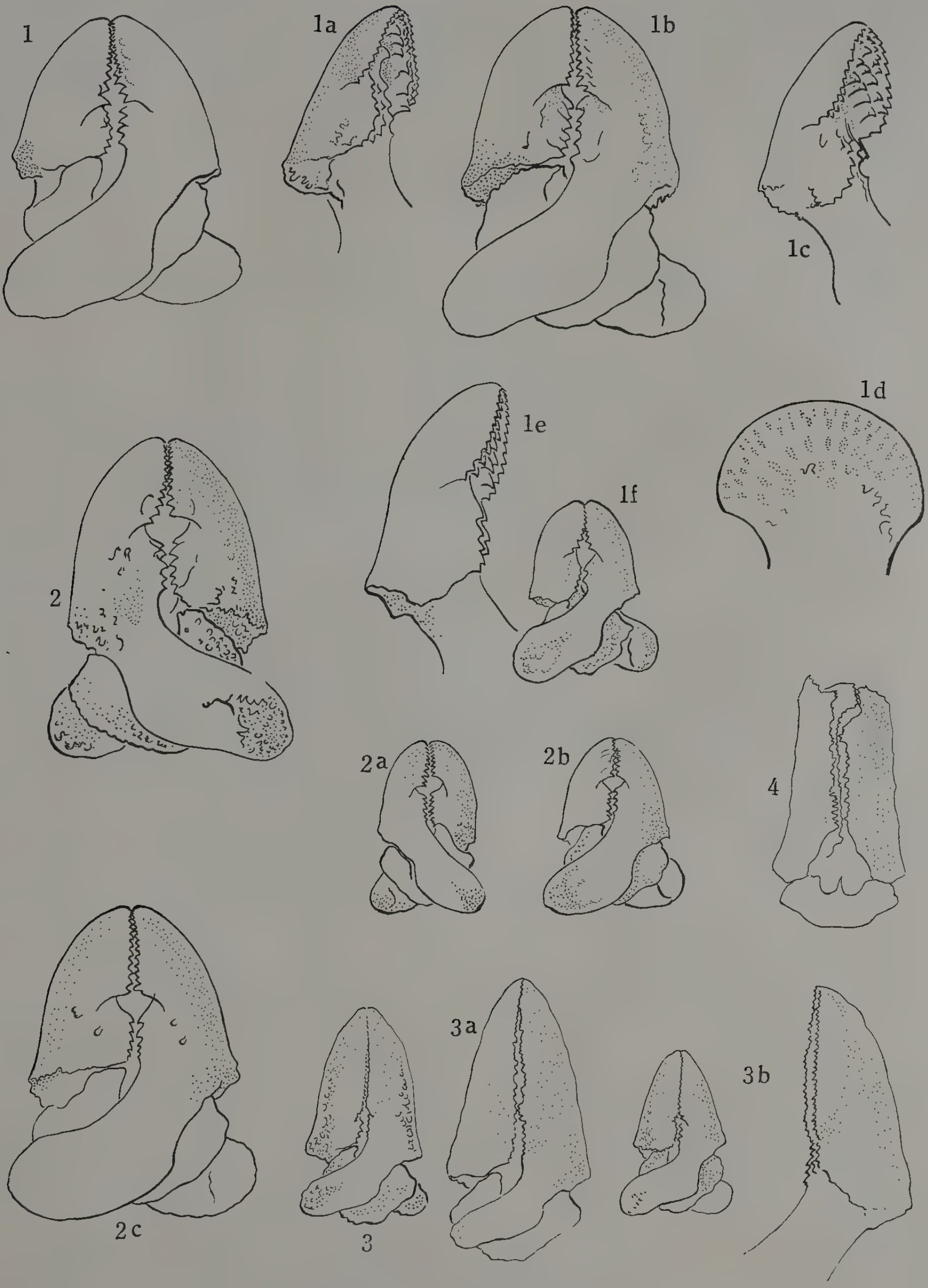
2*c*. Same specimen, 0.27 mm., ×200.

3. Same, type; a pedicellaria from an adambulacral spine, 0.34 mm., ×100.

3*a*. Same, type; a rare form of giant crossed pedicellaria from adambulacral spines, 0.45 mm., ×100.

3*b*. Same, Old Harbor, Kodiak; two adambulacral spine pedicellariae, 0.25 mm., ×100; jaw, ×200.

4. Same, type; a rare form of straight pedicellaria from adambulacral spine, 0.16 mm., ×50.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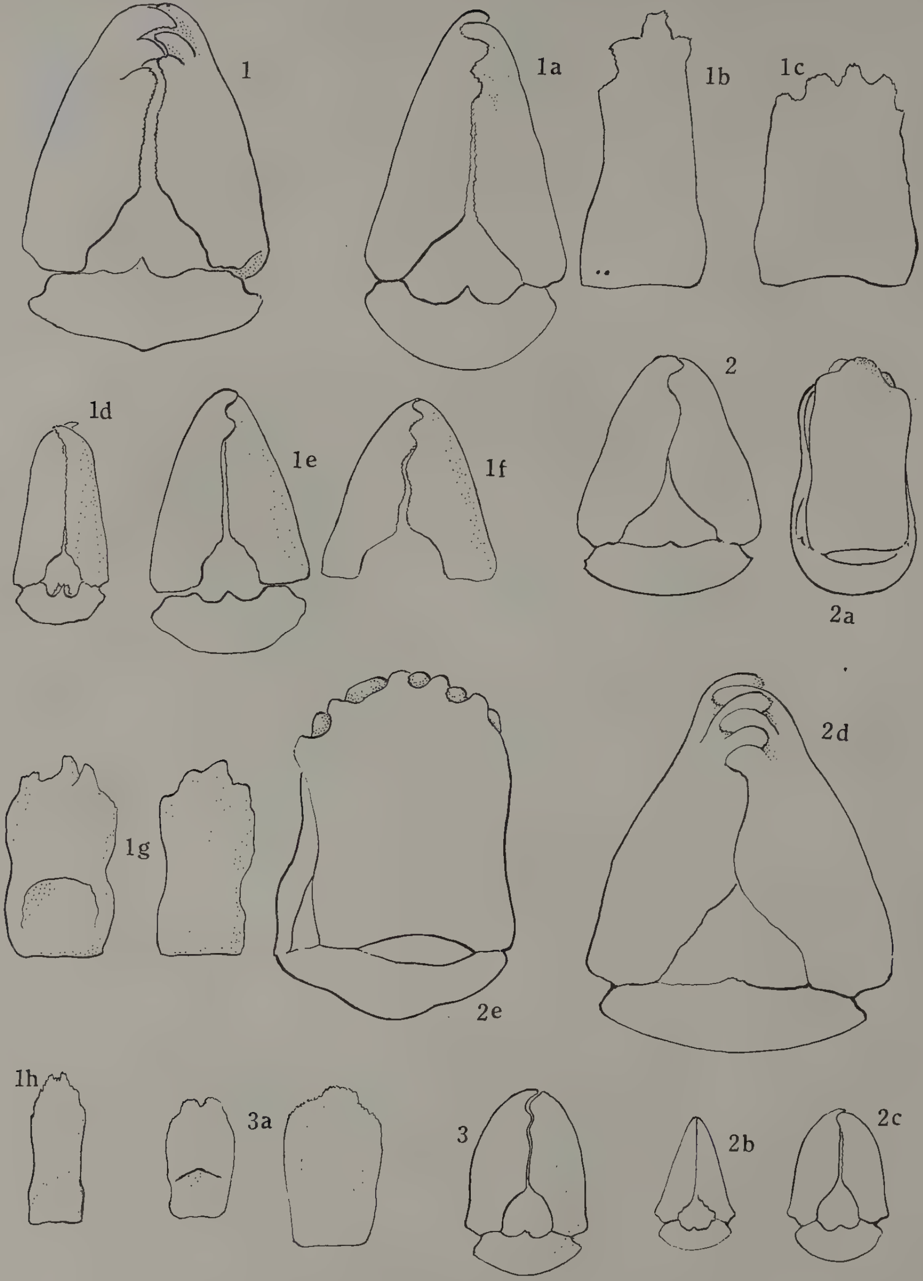
LEPTASTERIAS POLARIS ACERVATA

FOR EXPLANATION OF PLATE SEE PAGE FACING.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1, 2. LEPTASTERIAS POLARIS ACERVATA. 3. L. POLARIS BOREALIS

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 32

All straight pedicellariae

FIGURE 1. *Leptasterias polaris acervata* forma *aphelonota,* type; large-toothed pedicellaria from intermarginal channel 1.12 mm. long.

1*a*, 1*b*, 1*c*. Same, abactinal and lateral pedicellaria and two detached jaws, ×50.

1*d*. Same, from adambulacral spine, 0.63 mm., ×50.

1*e*, 1*f*. Same, Old Harbor, Kodiak, lateral, 0.8 mm., ×50.

1*g*. Same specimen; two jaws of an axillary pedicellaria, of the type common in the type specimen but rare in this.

1*h*. Same specimen, jaw of an actinal pedicellaria, ×50.

2, 2*a*. *Leptasterias polaris acervata* forma *acervata*, Cape Lisburne, Alaska, No. 6111, U. S. Nat. Mus.; two views of an intermarginal pedicellaria 0.75 mm. long, ×50.

2*b*, 2*c*. Same specimen, small abactinal pedicellariae.

2*d*, 2*e*. Same, station 3496; two views of intermarginal pedicellariae, 1.2 mm. long, ×50. This and some other specimens from the region of the Pribilof Islands have very large straight pedicellariae.

3, 3*a*. *Leptasterias polaris borealis*, Western Bank, No. 14339, U. S. Nat. Mus., very large specimen. Side view of the largest intermarginal pedicellaria, 0.58 mm. long, and two detached jaws.

PLATE 33

Leptasterias polaris katherinae, except Figure 7

FIGURE 1. Cotype No. 111, abactinal crossed pedicellaria, 0.27 mm., ×200.

1*a*. Jaws from (left) a superomarginal and (right) an abactinal pedicellaria, 0.27 mm., ×200.

1*b*. Another type of abactinal pedicellaria, 0.26 mm., ×100.

1*c*, 1*d*, 1*e*. Adambulacral spine pedicellariae and parts; 1*d* is the inside view of tip of jaw; 1*e*, 0.3 mm. long; all ×100.

1*f*. Side view of carinal plate, showing three abactinal spines, ×10.

2, 2*a*. No. 1181, Museum of Comparative Zoölogy, Gulf of Georgia, two abactinal pedicellariae, the left 0.225 mm., ×100.

3. No. 110, Gray's 37*b* (smallest specimen), an abactinal crossed pedicellaria, 0.23 mm., ×100.

3*a*. Jaw of a pedicellaria from an adambulacral spine, 0.27 mm.

4, 4*a*. Type, straight pedicellariae, intermarginal channel, 0.5 and 0.6 mm., ×50.

4*b*. From furrow spine, 0.375 mm., ×50.

4*c*. Valve of same from inside, ×100.

4*d*. Basal piece, ×100.

4*e*. Valve of furrow spine pedicellaria, detached, 0.35 mm., ×100.

5. No. 110, Gray's 37*b*, an adambulacral straight pedicellaria similar to those from other parts of the body, ×100.

6. No. 1181, M. C. Z.; an abactinal straight pedicellaria, ×100.

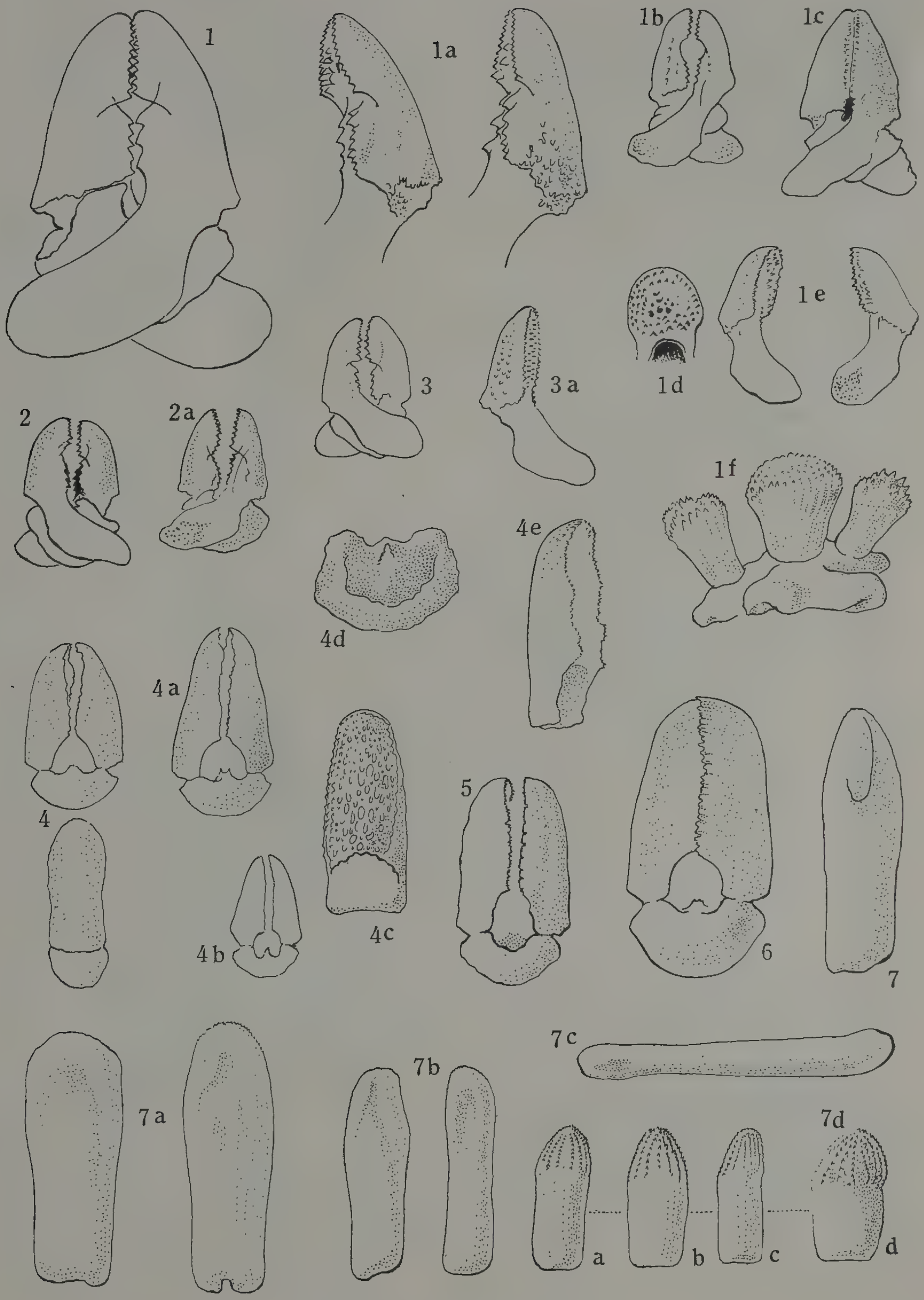
7. *Leptasterias polaris acervata* f. *aphelonota*, type, various spines, ×10.

7, 7*a*. Inferomarginal.

7*b*. Superomarginal.

7*c*. Subambulacral.

7*d*; *a*, *b*, *c*, *d*. Abactinal.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1–6. LEPTASTERIAS POLARIS KATHERINAE. 7. L. POLARIS ACERVATA

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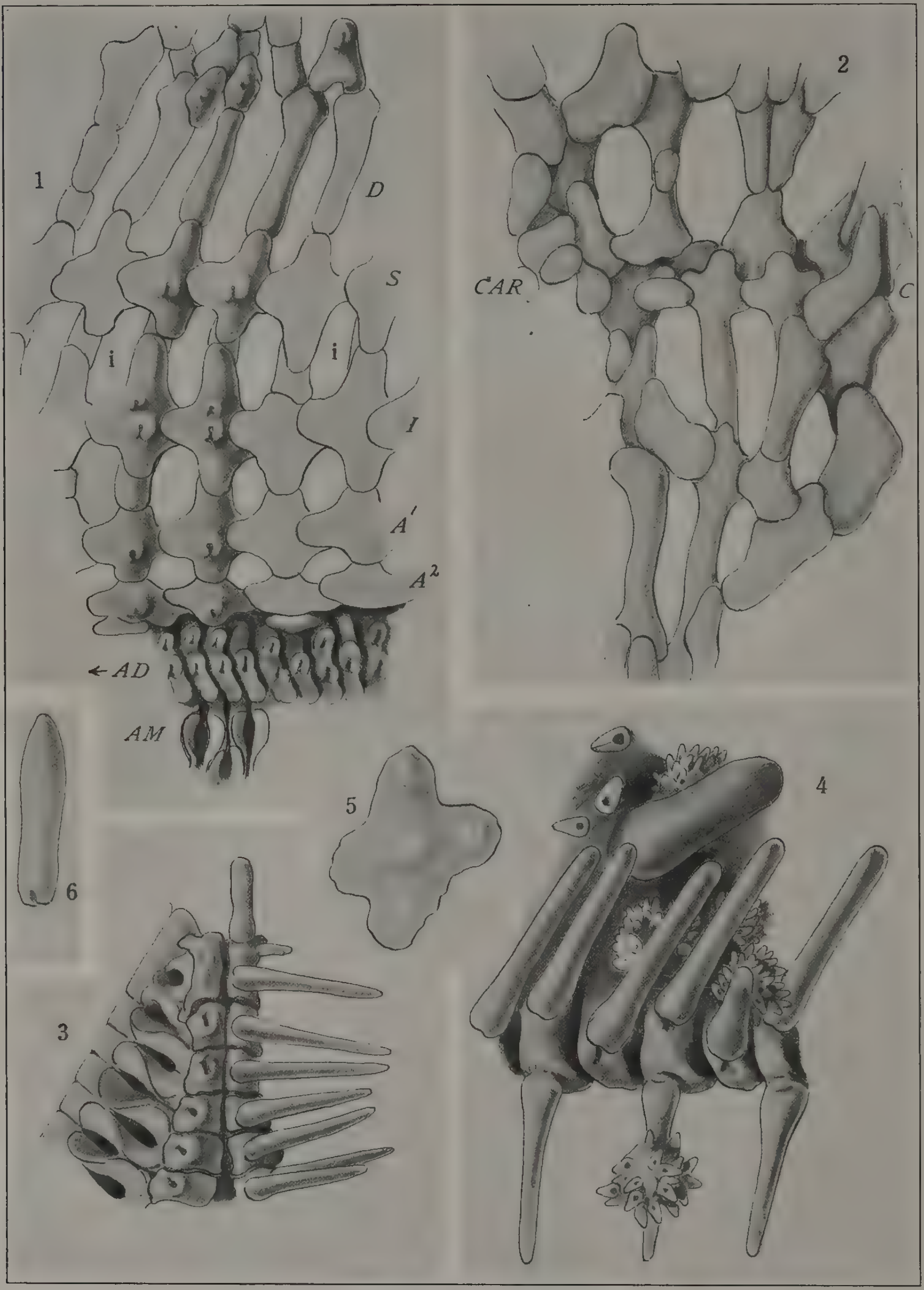
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LEPTASTERIAS POLARIS KATHERINAE

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 34

Leptasterias polaris katherinae

FIGURE 1. Cotype, skeleton of ray from the outside, showing actinal, lateral, and part of dorsal plates, base of ray to left, ×4; *D*, dorsolateral plates; *S*, superomarginals; *I*, inferomarginals; *i i*, intermarginal papular areas; A^1 A^2, outer and inner series of actinal plates; *AD*, adambulacrals; *AM*, outer ends of ambulacral ossicles.

2. Cotype, portion of dorsal skeleton from coelomic surface, showing mostly the connecting plates; *CAR–C*, radial line of plates; base of ray is to the right, ×4.

3. Type, plates of the mouth angle. The ambulacral plates are shown on the left. On the right are the mouth plates and the adoral adambulacrals, ×5.

4. Cotype, adambulacral armature near middle of ray. The thick spine above is an inner actinal.

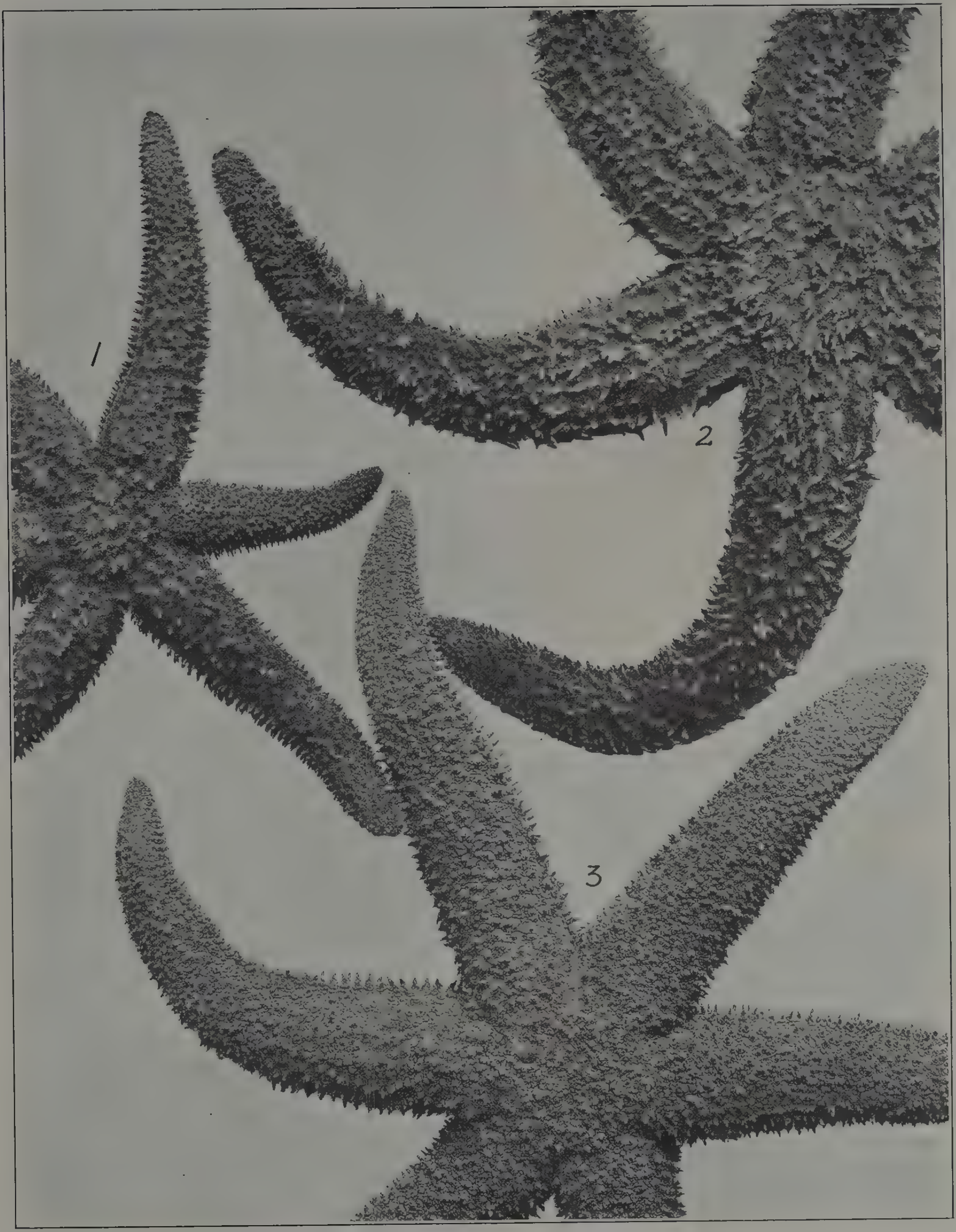
5. Cotype, a carinal plate, ×10.

6. Type, an inferomarginal spine, ×10.

PLATE 35

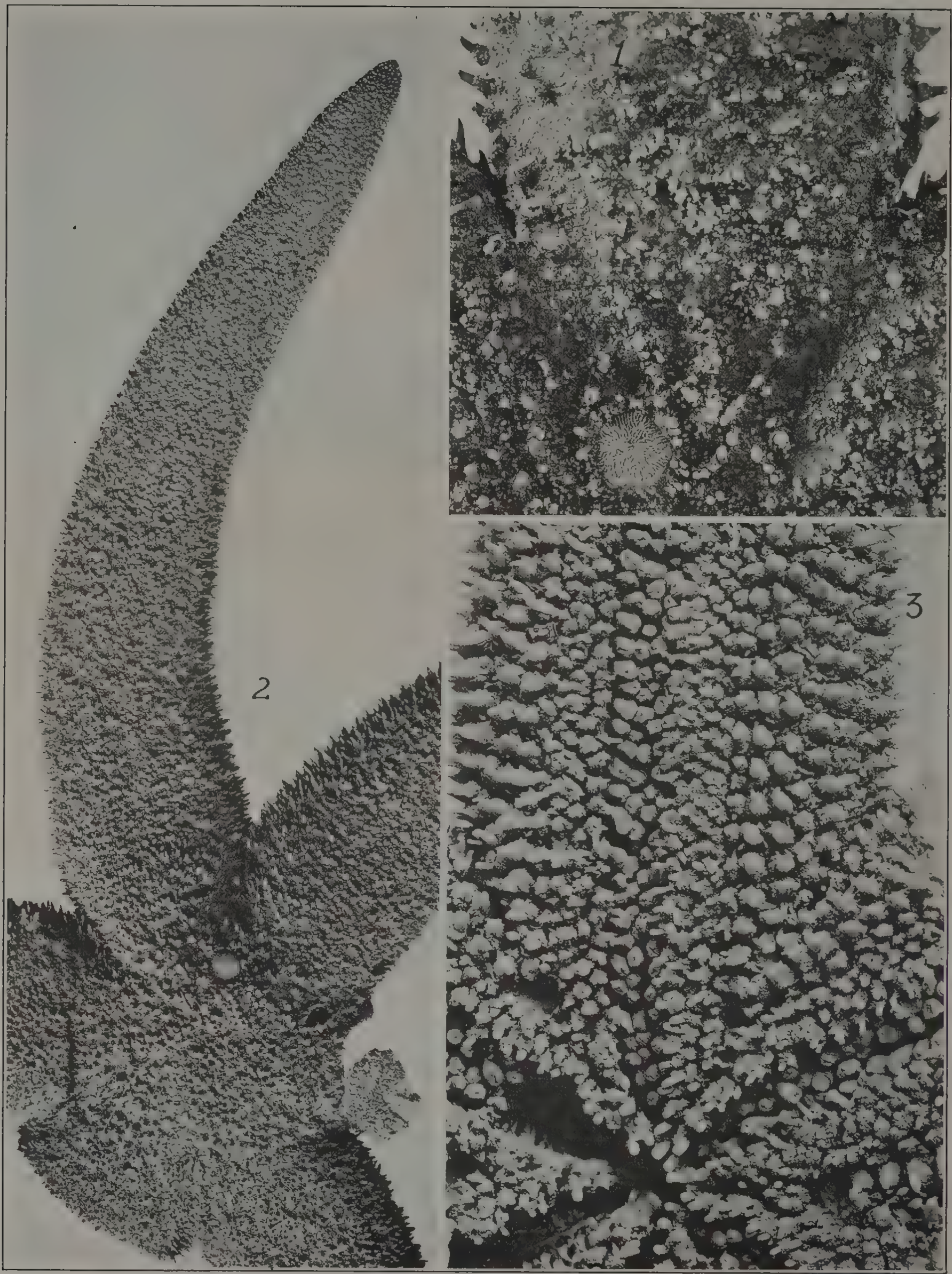
Leptasterias polaris borealis, ×4/5

FIGURE 1. Caribou Island, Labrador, No. 1307, Mus. Comp. Zoöl.
2. Gaspé, Quebec, No. 1308, Mus. Comp. Zoöl.
3. Caribou Island, Labrador, No. 1307, Mus. Comp. Zoöl. This is fairly typical *Leptasterias polaris borealis* and is one of the lot from which Perrier's type was derived.



Leptasterias polaris borealis

For explanation of plate see page facing.



1. LEPTASTERIAS POLARIS KATHERINAE. 2, 3. L. POLARIS ACERVATA FORMA APHELONOTA

FOR EXPLANATION OF PLATE SEE PAGE FACING.

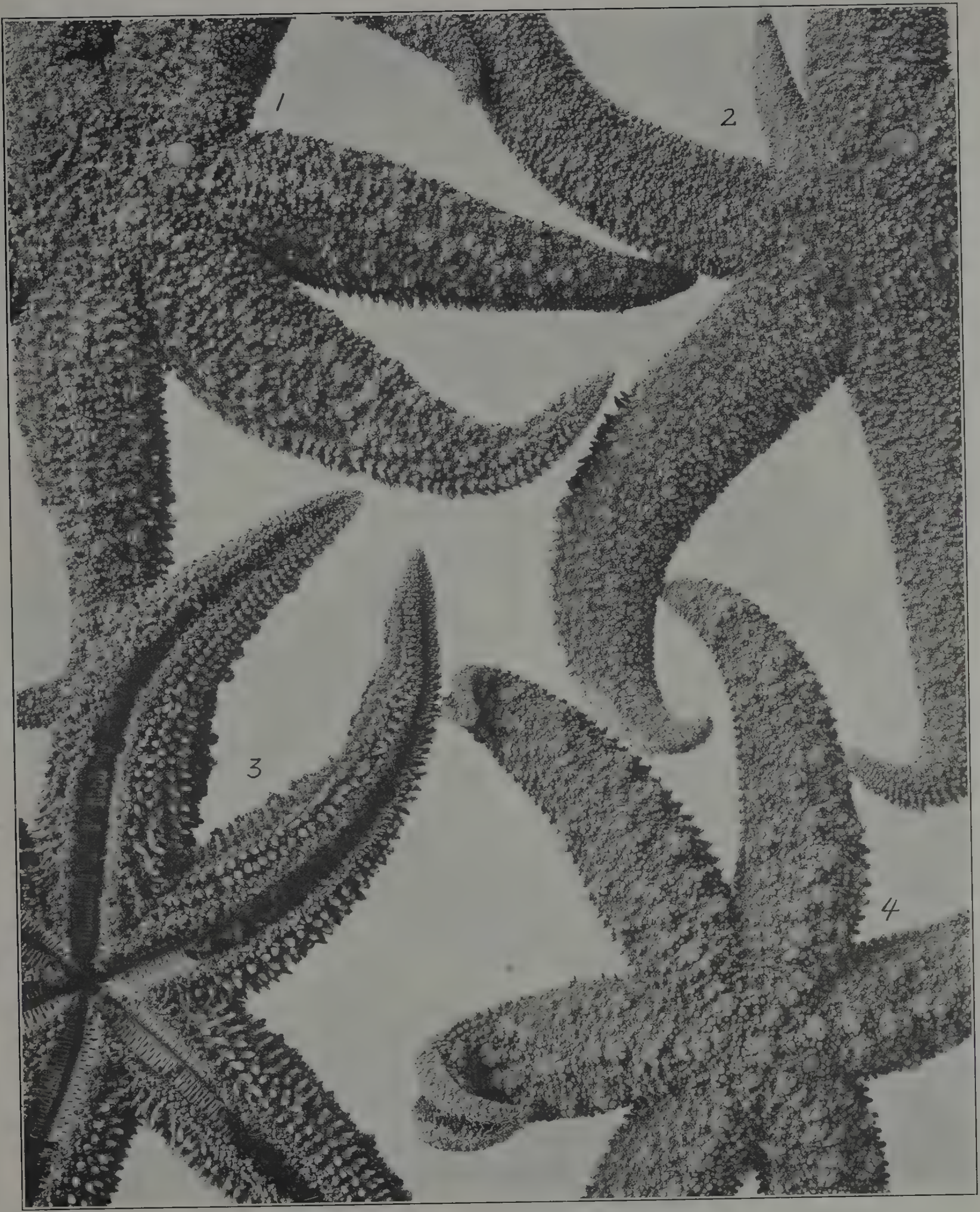
PLATE 36

FIGURE 1. *Leptasterias polaris katherinae*, portion of abactinal surface of type, ×2.
2. *Leptasterias polaris acervata* forma *aphelonota*, type, ×0.66.
3. Same, portion of actinal surface of type, ×1.6.

PLATE 37

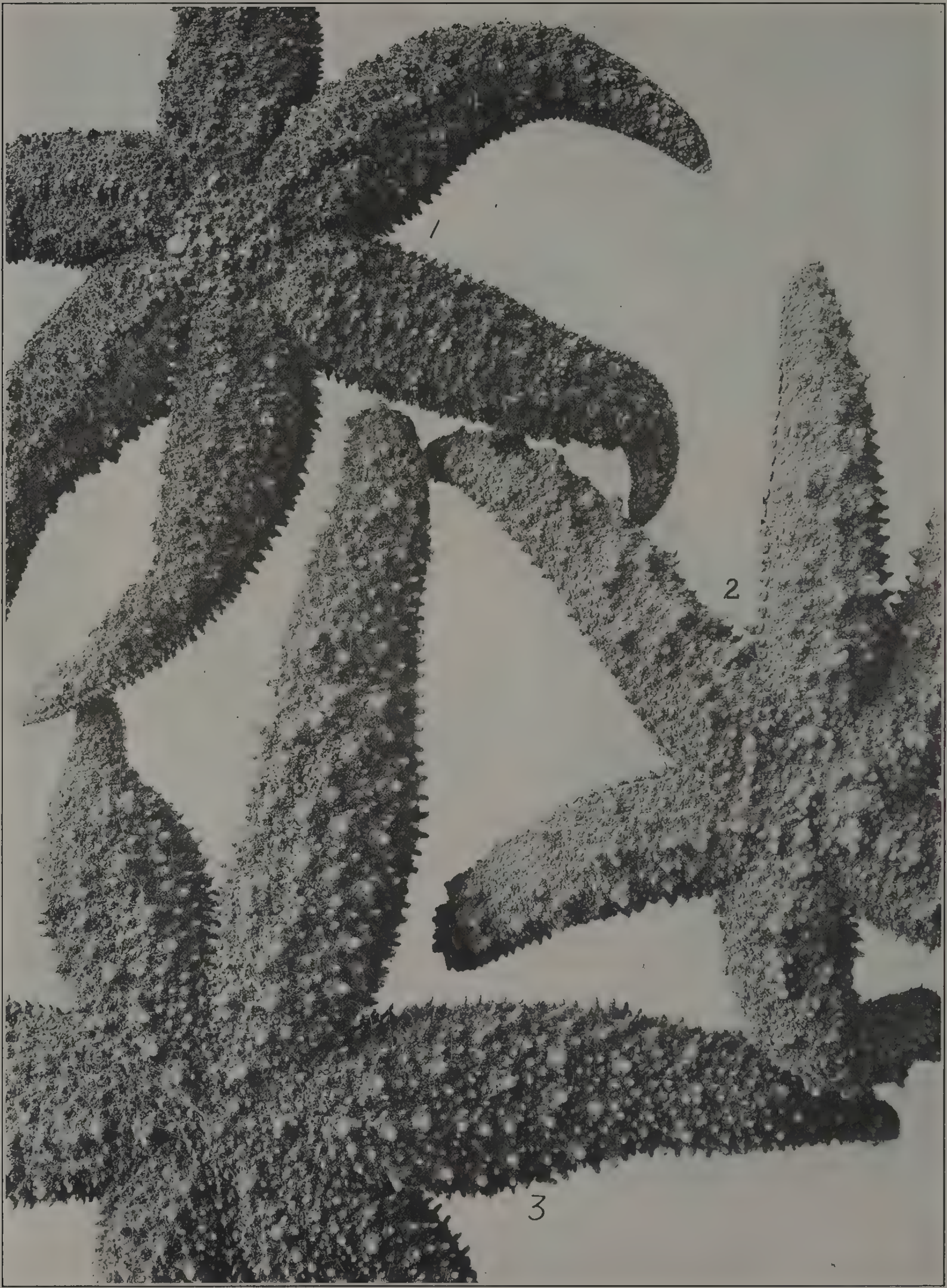
Leptasterias polaris acervata forma *acervata*, ×1¼

FIGURE 1. Station 3233, Bristol Bay, Bering Sea, shallow.
2. Station 3235, Bristol Bay shallow.
3. Station 3233 Bristol Bay, shallow.
4. Indian Point, Siberia, 17 fathoms.



Leptasterias polaris acervata forma acervata

For explanation of plate see page facing.



Leptasterias polaris acervata

For explanation of plate see page facing.

PLATE 38

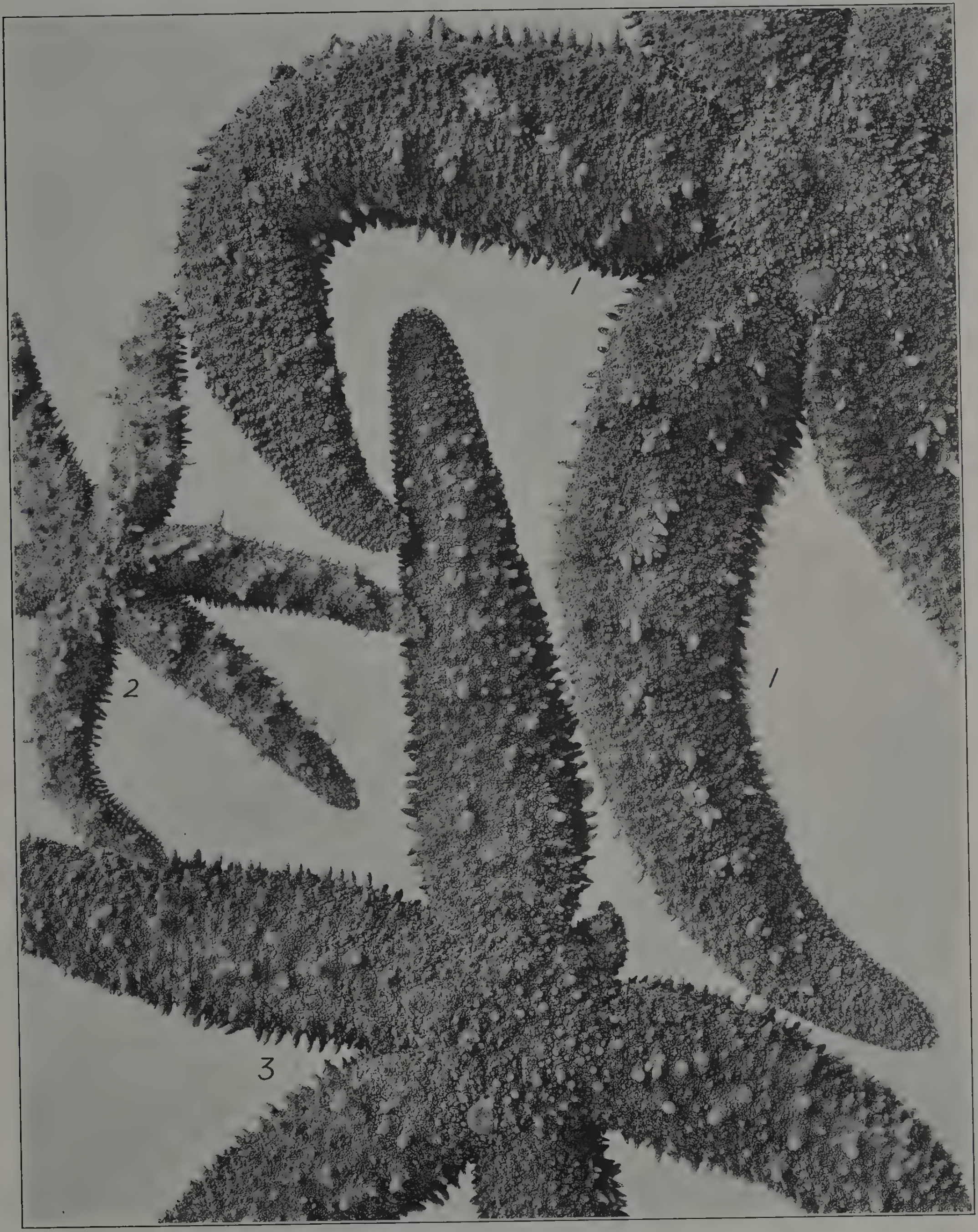
Leptasterias polaris acervata, ×1⅙

FIGURE 1. Forma *acervata,* station 3233, Bristol Bay, Bering Sea.
2. Forma *acervata—polythela,* north of Bering Strait (*Corwin,* No. 15818).
3. Forma *polythela,* station 3277, north of end of Alaskan Peninsula.

PLATE 39

Leptasterias polaris acervata forma *polythela*, natural size

FIGURE 1. Station 3251, north coast Unimak Island.
2. Station 3518, Bering Sea, near St. Matthew Island.
3. Station 3439, Bering Sea, west of Pribilof Islands.



LEPTASTERIAS POLARIS ACERVATA FORMA POLYTHELA

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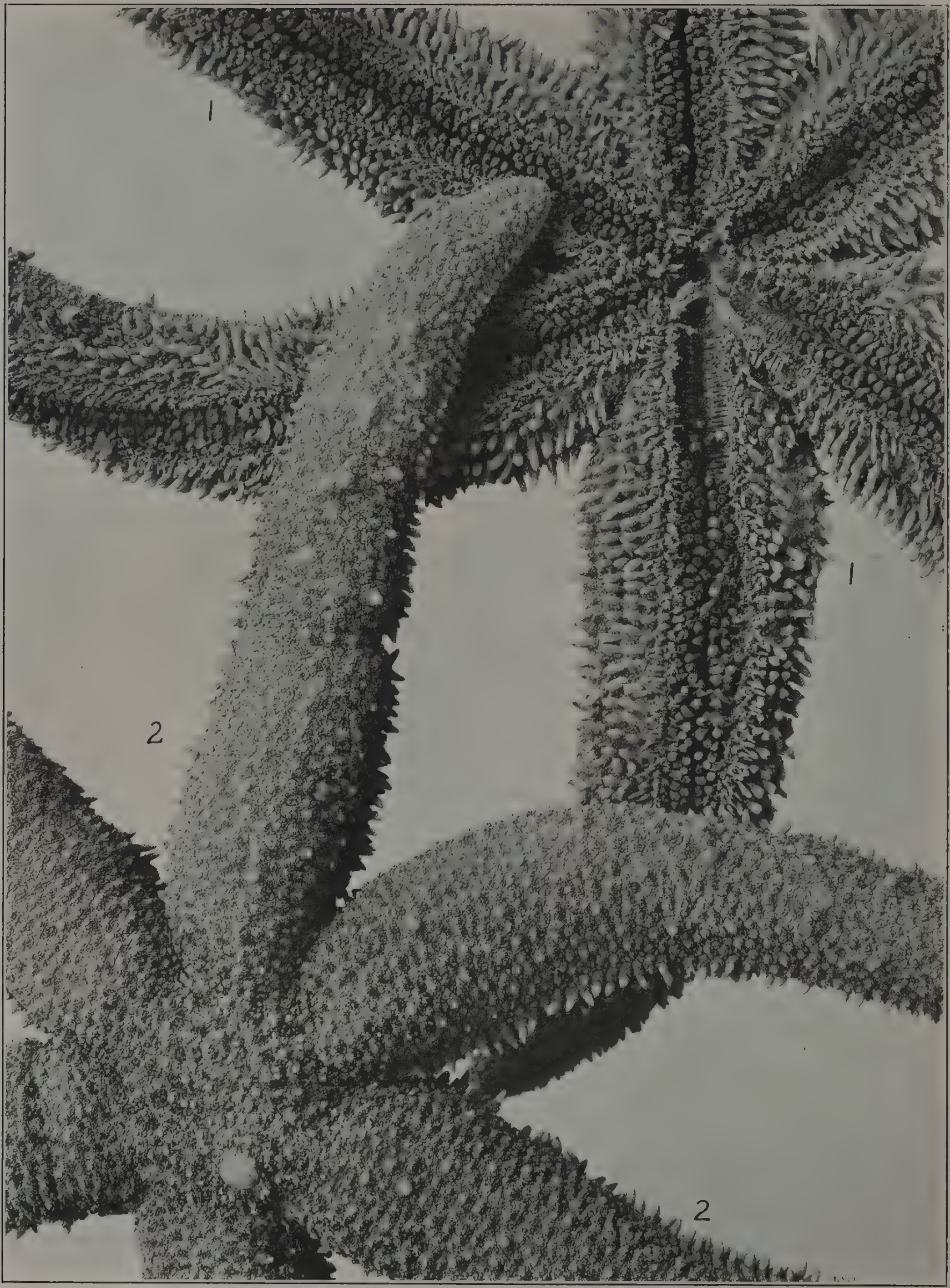


LEPTASTERIAS POLARIS ACERVATA FORMA POLYTHELA

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 40

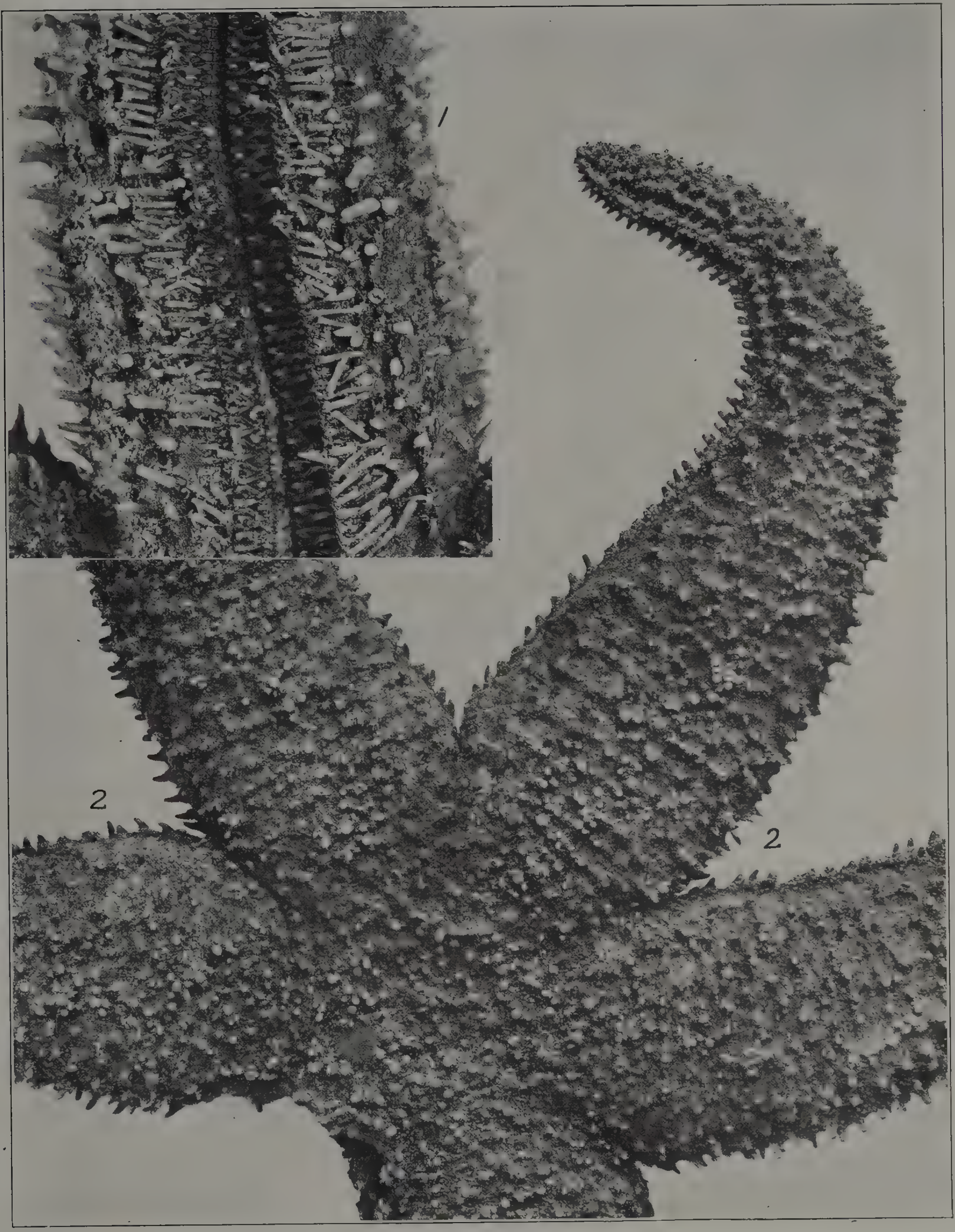
Leptasterias polaris acervata forma *polythela,* natural size

FIGURE 1. Station 3251, north coast Unimak Island.
2. Station 3440, Bering Sea, west of Pribilof Islands.

PLATE 41

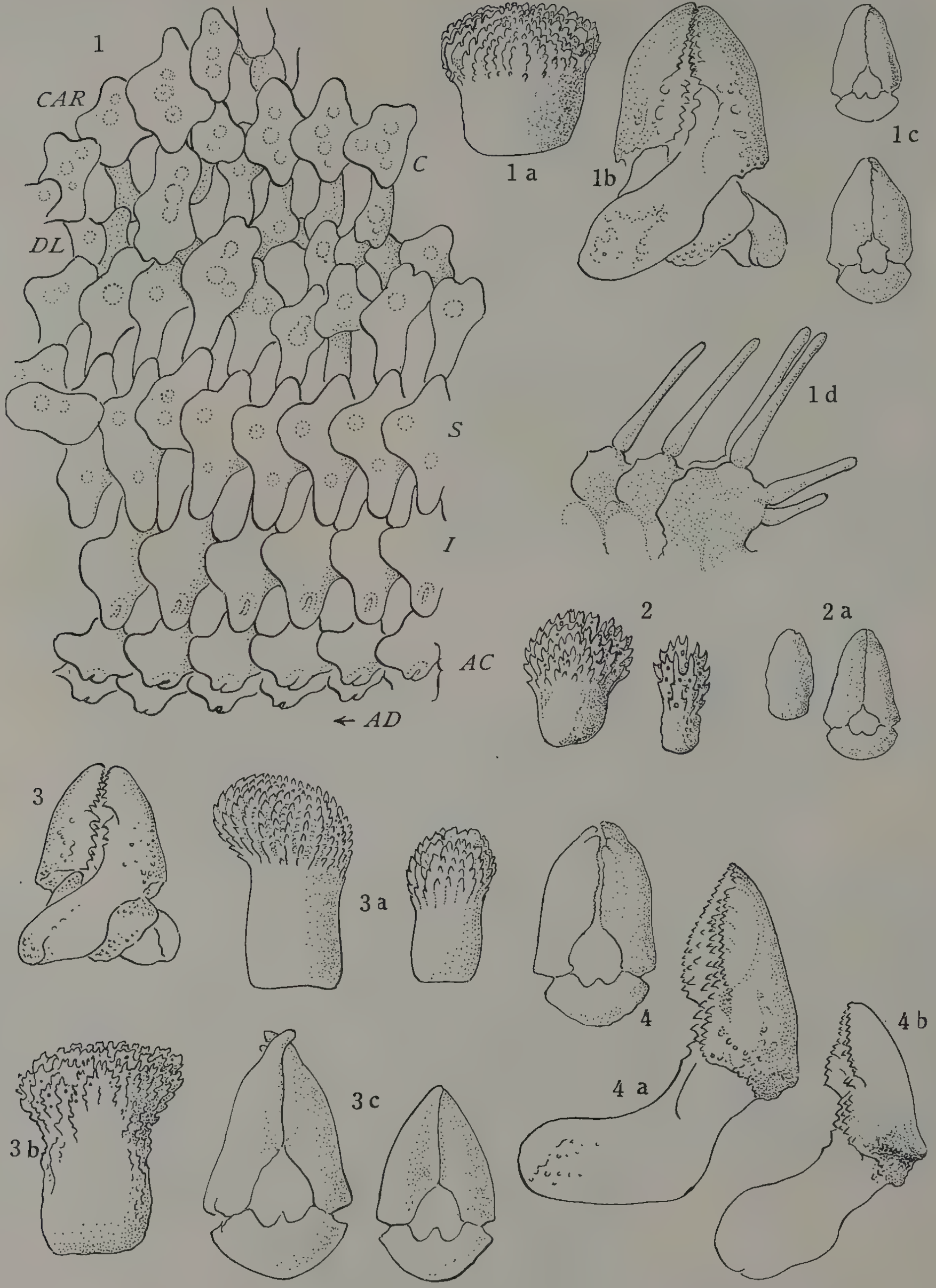
Leptasterias polaris katherinae

FIGURE 1. Portion of actinal surface of type, speciman 107 of type series, ×2.
2. Cotype, specimen 111, of type series, ×1⅓.



LEPTASTERIAS POLARIS KATHERINAE

FOR EXPLANATION OF PLATE SEE PAGE FACING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1. Leptasterias camtschatica. 2–4. L. camtschatica dispar and formae

For explanation of plate see page facing.

PLATE 42

FIGURE 1. *Leptasterias camtschatica;* projection of skeleton from actinals to carinals, at base of ray, which is at left, ×10; *AC*, two series of actinal plates; *AD*, direction of base of ray; *CAR–C*, carinal series; *DL*, dorsolaterals; *I*, inferomarginals; *S*, superomarginals.

1*a*. Same, dorsal spinelet, 0.5 mm., ×50.
1*b*. Same, an abactinal crossed pedicellaria, 0.225 mm., ×200.
1*c*. Same, two lateral straight pedicellariae, 0.36 and 0.46 mm., ×50.
1*d*. Same, Petropavlovsk, mouth plates, ×10.
2. *L. camtschatica dispar* f. *nesiotis*; two abactinal spinelets, 0.4 and 0.37 mm., ×50.
2*a*. Same, intermarginal pedicellaria of type (0.42 mm.) and a jaw, ×50.
3. *L. camtschatica dispar* f. *nitida;* abactinal crossed pedicellaria, 0.16 mm., ×200 (St. Paul, Pribilofs).
3*a*. Same, Pribilof Islands; two abactinal spinelets 0.7 and 0.5 mm., ×50.
3*b*. Same, Unalaska, abactinal spinelet.
3*c*. Same, two straight pedicellariae, 0.8 and 0.63 mm., ×50.
4. *L. camtschatica dispar* f. *dispar*, Attu Island, straight pedicellaria, 0.63 mm., ×50.
4*a*. Same, Nazan Bay, Atka; jaw of crossed pedicellaria, 0.27 mm., ×200.
4*b*. Same, St. George, Pribilof Islands, 0.225 mm.

PLATE 43

FIGURE 1. *Leptasterias aleutica;* two abactinal spinelets, 0.38 and 0.4 mm., ×100.

1*a*, 1*a′*. Same crossed pedicellariae; *a*, Adakh; *a′*, Atka (0.2 mm.), ×200.

1*b*, 1*c*. Same, straight pedicellariae, 0.3 and 0.24 mm., ×100.

2. *Leptasterias leptodoma;* straight pedicellaria, 0.5 mm., ×100.

2*a*. Same; abactinal crossed pedicellaria, 0.24 mm., ×200.

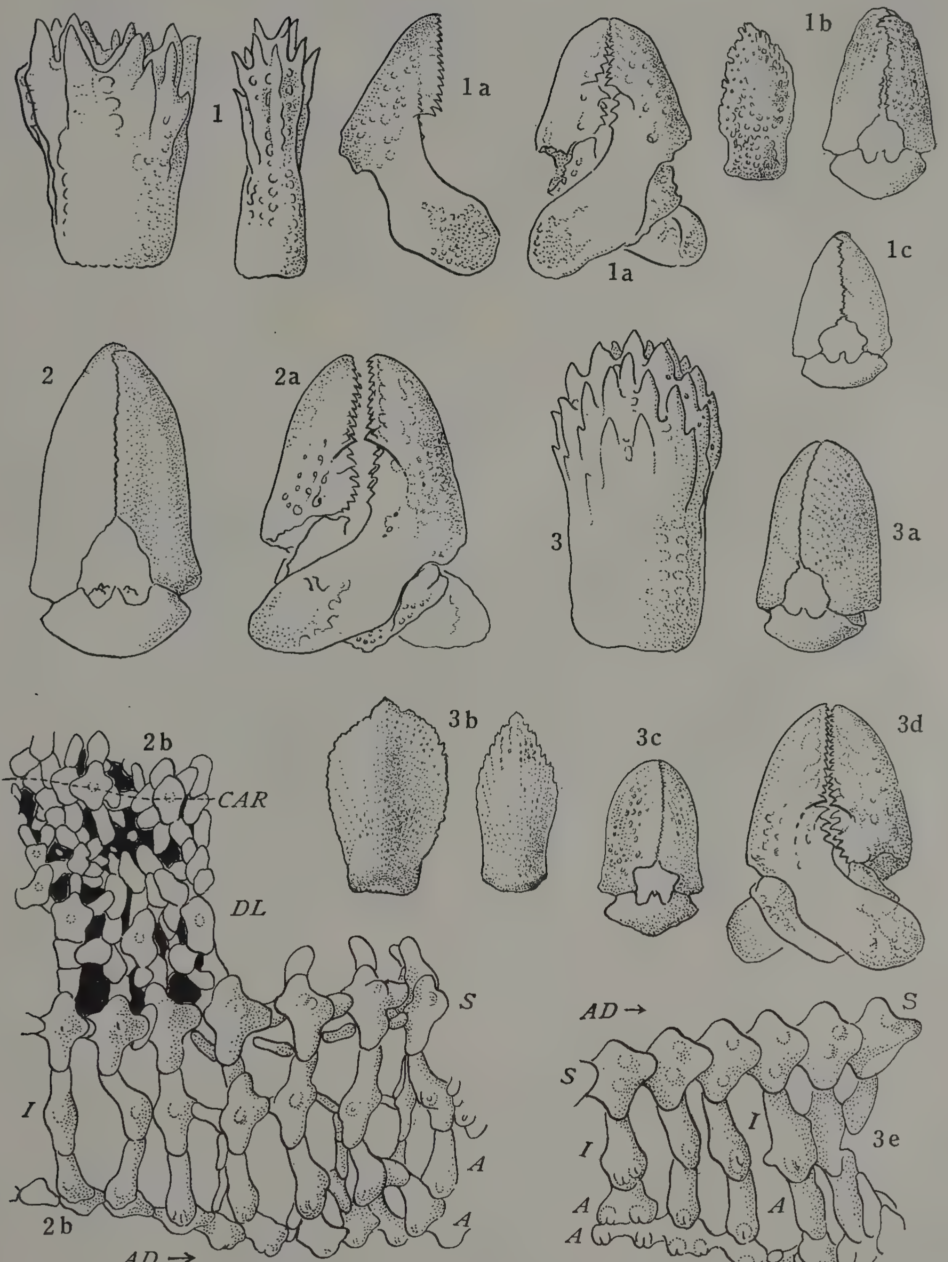
2*b*. Same, Adakh Island; projection of skeleton of base of ray from the carinals *CAR* to actinals *A*, *A; AD*, direction of base of ray, *DL*, dorsolaterals, very thin and irregular; *I*, inferomarginals; *S*, superomarginals, ×10.

3. *Leptasterias asteira;* abactinal spinelet, 0.5 mm., ×100.

3*a*, 3*b*, 3*c*. Same, views of straight pedicellariae, ×50; 3*a*, 0.34 mm.

3*d*. Same, abactinal crossed pedicellaria, ×200.

3*e*. Same, projection of marginal (*S*, *I*) and actinal plates (*A A*), base of ray; *AD* direction of disk.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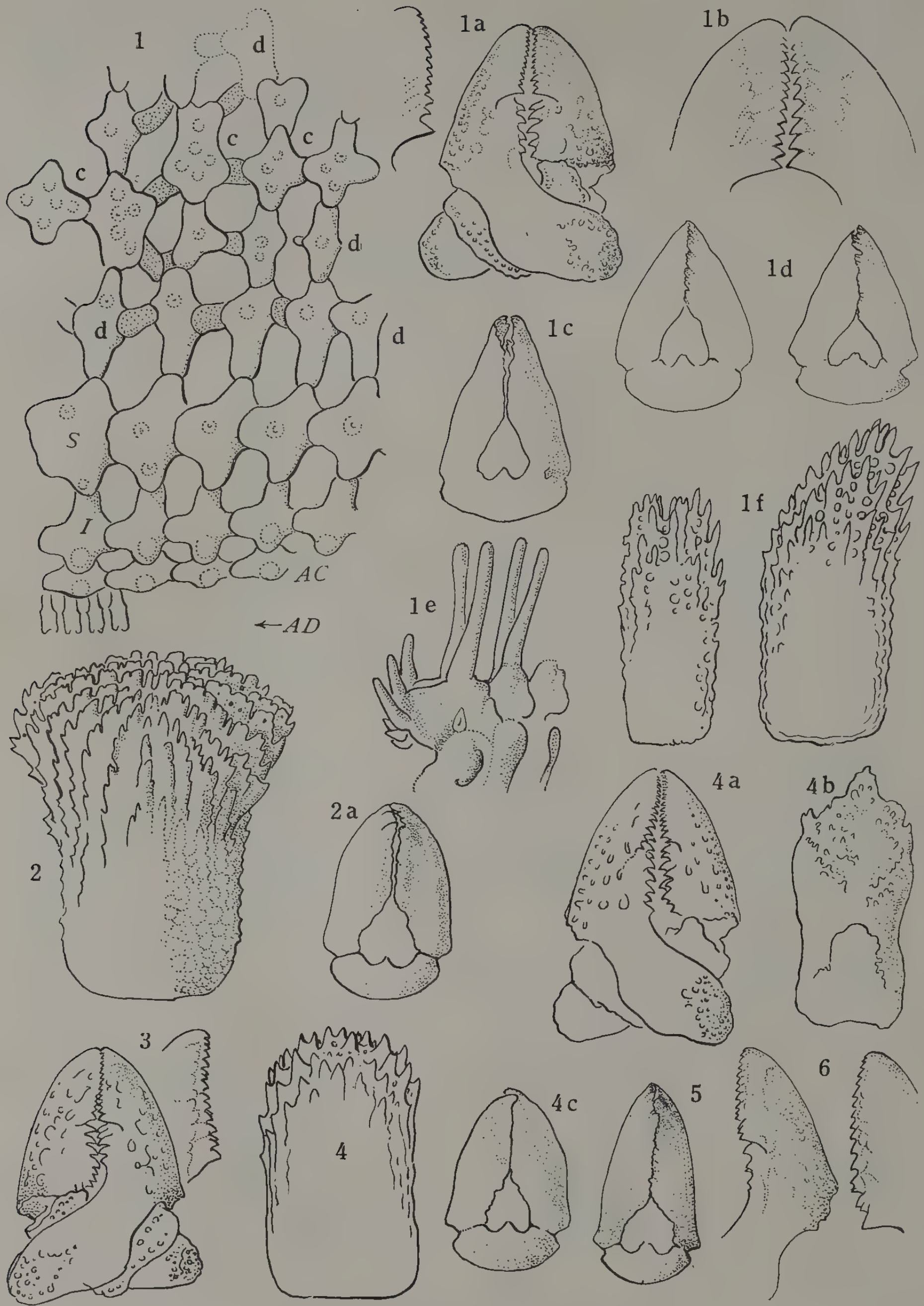
1. Leptasterias aleutica. 2. L. leptodoma. 3. L. asteira

For explanation of plate see page facing.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LEPTASTERIAS HEXACTIS AND FORMAE

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 44

FIGURE 1. *Leptasterias hexactis,* cotype, No. 1368, ×10. Projection of skeleton from carinals (*c, c, c*) to actinals (*AC*); a few adambulacrals indicated on left; *AD,* direction of disk; *d, d, d,* dorsolaterals; *I,* inferomarginals; *S,* superomarginals.

1*a.* Same specimen; abactinal crossed pedicellaria, 0.2 mm., ×200; tip of left jaw on left, ×400.

1*b.* End of another pedicellaria ×400. The outer face is on right instead of left as in 1*a.*

1*c,* 1*d.* Same specimen, three straight pedicellariae, 0.67, 0.58, 0.54 mm. ×50.

1*e.* Same specimen, mouth plates and two adambulacrals, ×10.

1*f.* Same specimen; two abactinal spinelets, 0.4 and 0.5 mm., ×100.

2. *L. hexactis* f. *siderea,* Kodiak Island; abactinal spinelet, 0.54 mm., ×100.

2*a.* Same; pedicellaria from large intermediate specimen, Homer, Alaska, 0.6 mm., ×50.

3. *L. hexactis* f. *plena,* Forrester Island, Alaska, abactinal pedicellaria, 0.2 mm., ×200; and outer face of terminal lip of another, ×400.

4. *L. hexactis* f. *aspera,* Kodiak; abactinal spinelet, 0.43, ×100.

4*a.* Same, Cordova; abactinal pedicellaria, 0.25, ×200.

4*b.* Same, Cordova; jaw of a straight pedicellaria, ×100.

4*c.* Same, Cordova; straight pedicellaria, 0.58 mm., ×50.

5. *L. hexactis* f. *hexactis,* intergrade with *vancouveri* (Class III), San Juan Islands, Wash., ×50.

6. *L. hexactis* f. *regularis,* San Juan Islands, Wash.; crossed pedicellaria, ×200 (left) and terminal lip, ×400.

PLATE 45

FIGURE 1. *Leptasterias hexactis vancouveri*, San Juan Islands, Wash., ×5. Projection of skeleton, base of ray of a large specimen; *CAR*, carinals; *DL*, dorsolaterals; *S*, superomarginals; *I*, inferomarginals; *AC 1, 2*, two series of actinals; *AD*, direction of disk.

1*a*, 1*b*. Same, two abactinal spinelets, 0.5 mm., ×100.

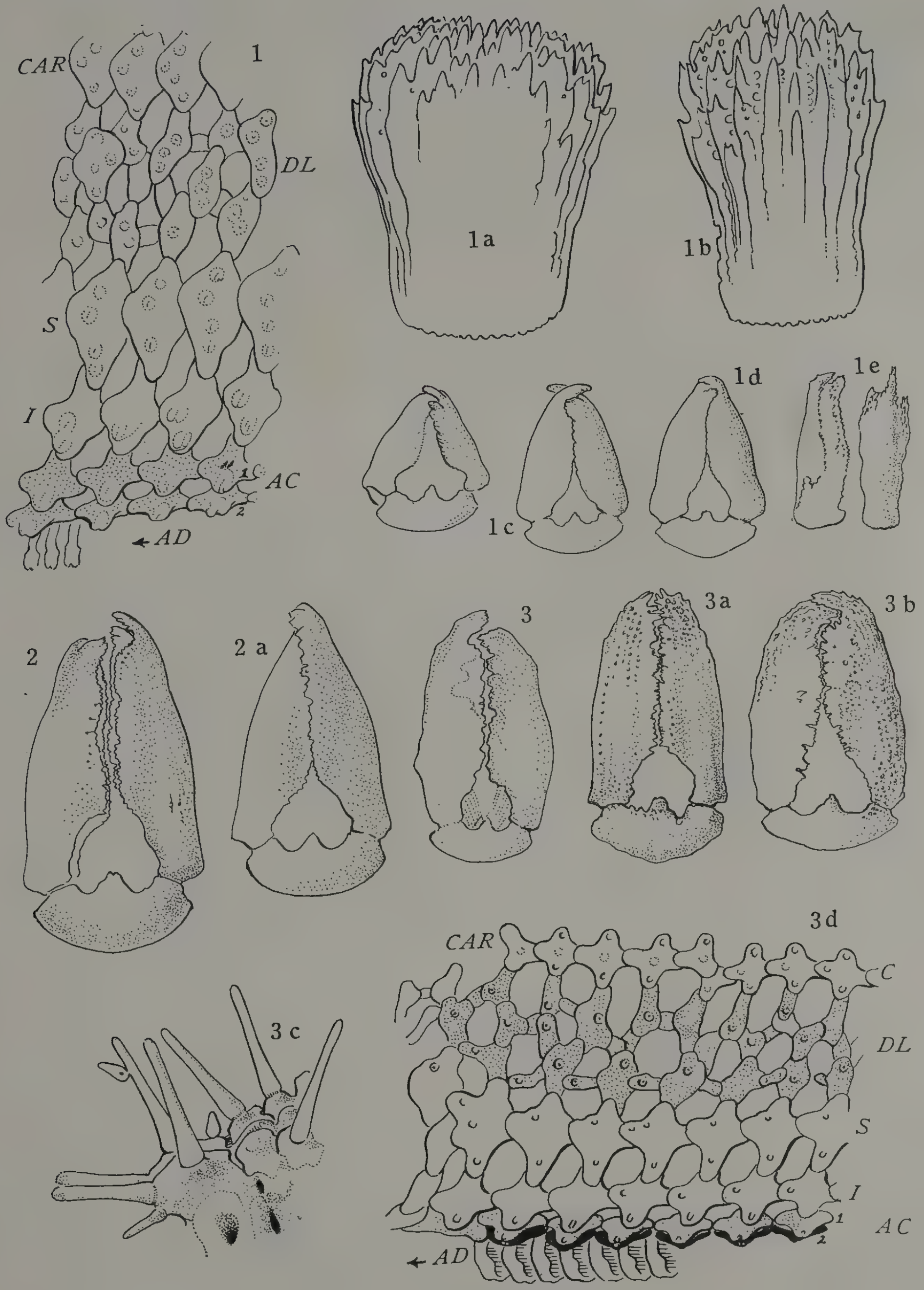
1*c*, 1*d*, 1*e*. Same, straight pedicellariae, 0.45, 0.54, 0.58 mm., ×50.

2, 2*a*. *Leptasterias hexactis* f. *aspera*, Kodiak, straight pedicellariae, 0.55 and 0.46 mm., ×100.

3, 3*a*, 3*b*. *Leptasterias pusilla*, straight pedicellariae, ×50; 3, 3*b*, from actinal interradial region; 3*a*, from adambulacral spinelet.

3*c*. Same, mouth and two pairs of adambulacral plates, ×20.

3*d*. Same, projection of skeleton, base of ray, ×10; *CAR–C*, carinals; *DL*, dorsolaterals, stippled; *S*, superomarginals; *I*, inferomarginals; *AC 1, 2*, actinals, the second series in solid black; *AD*, direction of disk, and seven adambulacral plates.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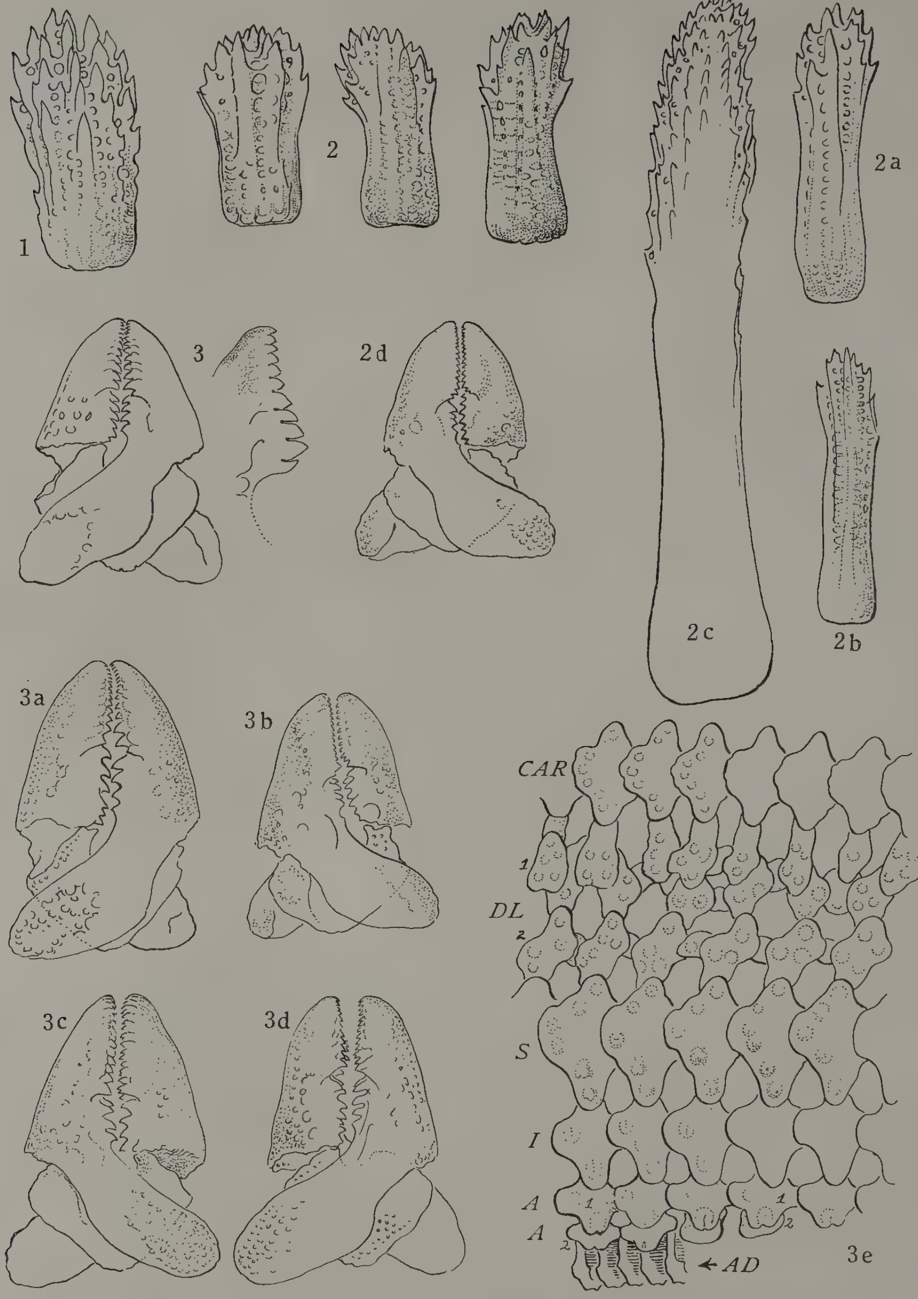
1. Leptasterias hexactis vancouveri. 2. L. hexactis f. aspera. 3. L. pusilla

For explanation of plate see page facing.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1. Leptasterias hexactis vancouveri. 2. L. pusilla. 3. L. aequalis

For explanation of plate see page facing.

Plate 46

Figure 1. *Leptasterias hexactis vancouveri*, a small dorsolateral spinelet, ×100.

2. *Leptasterias pusilla;* dorsal spinelets, 0.32 to 0.36 mm., ×100.

2*a*, 2*b*. Same, dorsolateral spinelets, ×100.

2*c*. Actinal spinelet, ×100.

2*d*. An abactinal crossed pedicellaria, ×200.

3. *Leptasterias aequalis*, Monterey Bay; abactinal crossed pedicellaria, 0.21 mm., ×200, and, to right, outer face of terminal lip showing enlarged lateral teeth, ×400.

3*a*. Same, Friday Harbor, Wash., abactinal, 0.24 mm.

3*b*. Same, Monterey, abactinal, 0.2 mm., ×200.

3*c*. Same, Monterey, from an adambulacral spinelet, 0.24 mm.

3*d*. Same, from an actinal spinelet, 0.23 mm.

3*e*. Same, Monterey, ×10; projection of skeleton from carinals, *CAR* to actinals *AA*; *DL*, *1*, *2*, dorsolaterals; *S*, superomarginals; *I*, inferomarginals; *AD*, direction of disk; five adambulacrals shown at bottom.

Plate 47

Leptasterias aequalis

Figures 1, 1*a*, 1*b*. Monterey Bay, dorsolateral spinelets from typical large specimen, 0.55, 0.7, and 0.5 mm., ×100.

1*c*. Abactinal spinelets from a small, slender-spined individual with R 12 mm., ×100.

1*d*. Carinal spinelets from a small specimen (R 13 mm.) with short granuliform spinelets, 0.19 and 0.27 mm., ×100.

1*e*, 1*f*. Abactinal spinelets (Monterey specimen), 0.36 and 0.45 mm., ×100.

2. Mouth plates and two adambulacrals, from typical large Monterey specimen.

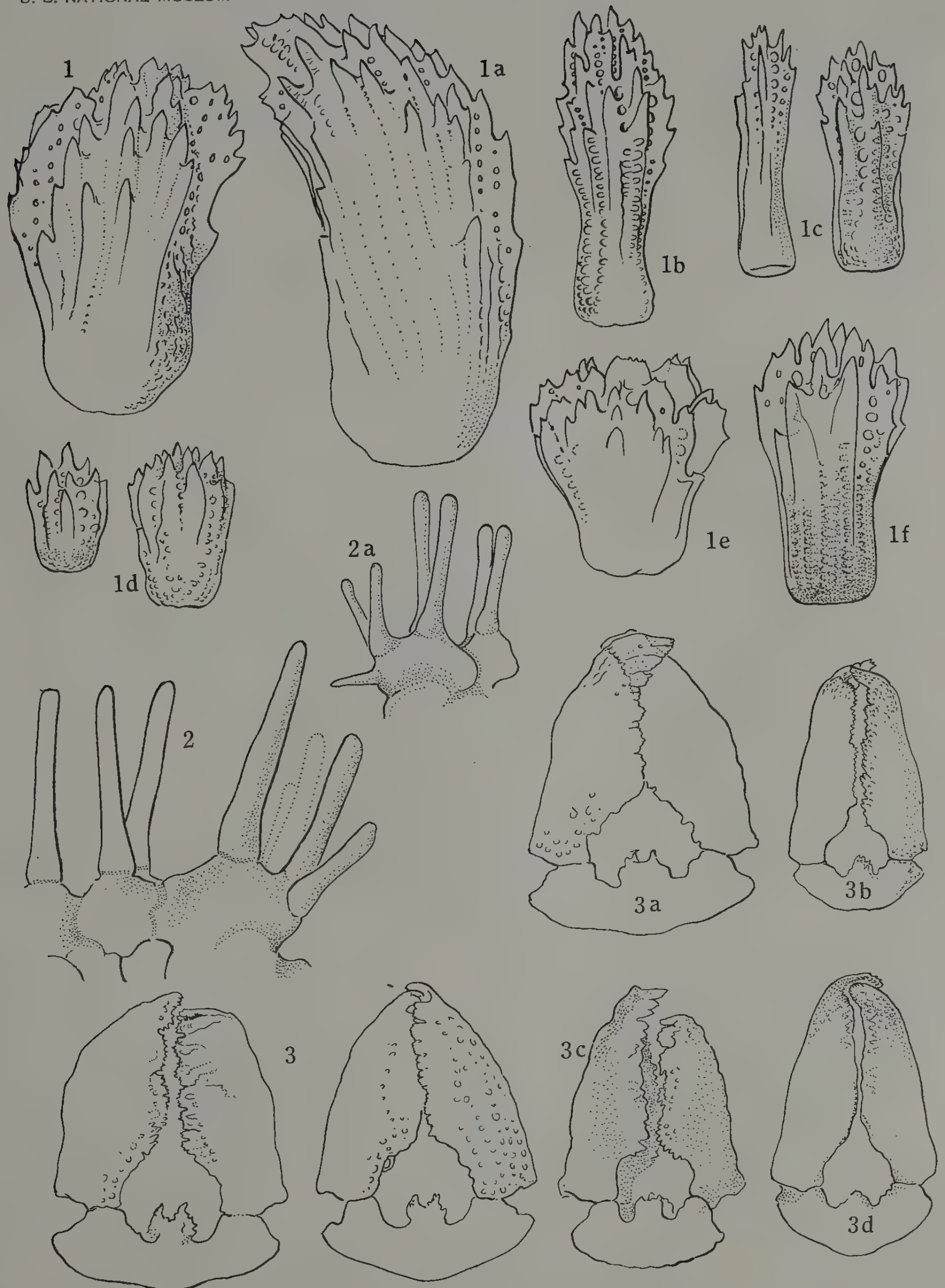
2*a*. Another variation.

3. Two straight pedicellariae from ambulacral furrow, 0.48 mm., ×100.

3*a*, 3*c*. Two pedicellariae from adambulacral spinelets, 0.24 and 0.225 mm., ×200 (about half as large as 3).

3*b*. One of the narrower straight pedicellariae from oral spinelet, 0.4 mm., ×100.

3*d*. A similar one from the actinal interradial region, 0.45 mm., ×100.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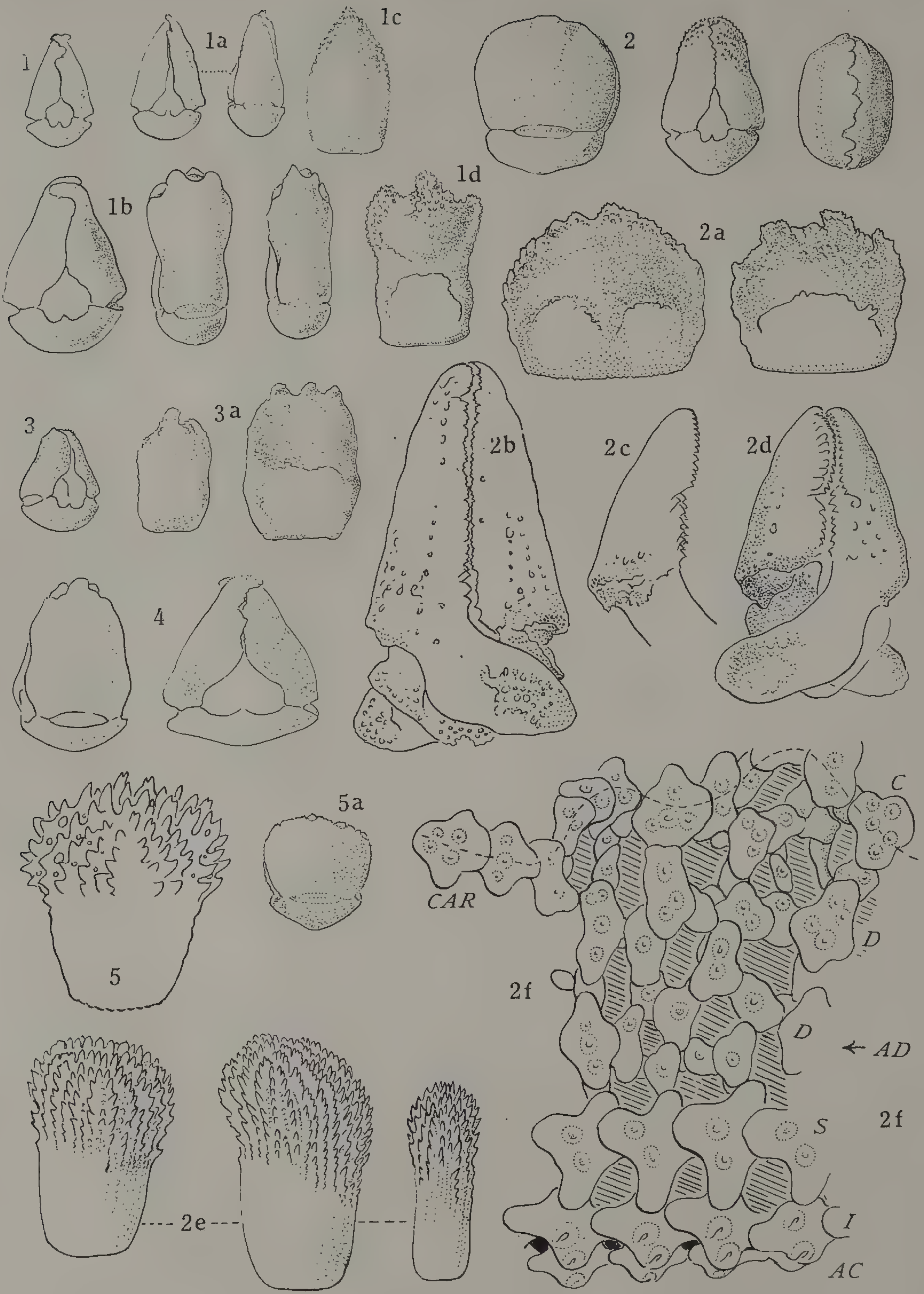
LEPTASTERIAS AEQUALIS

FOR EXPLANATION OF PLATE SEE PAGE FACING.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S
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1. LEPTASTERIAS ALASKENSIS ASIATICA. 2. L. ALASKENSIS. 3. L. ALASKENSIS F. SHUMAGINENSIS. 4. L. ALASKENSIS MULTISPINA. 5. L. ALASKENSIS F. PRIBILOFENSIS

FOR EXPLANATION OF PLATE SEE PAGE FACING.

Plate 48

Figures 1, 1*a*. *Leptasterias alaskensis asiatica,* type, ×25. Intermarginal straight pedicellariae for comparison with Figure 2, same magnification, Left figure, 0.72 mm.

1*b*. Same, Bering Island, 0.58 mm., ×50 (twice enlargement of 1).

1*c*, 1*d*. Same, Simushir, Kuril Islands, two detached jaws, ×50, for comparison with 2*a*, same enlargement.

2. *Leptasterias alaskensis* f. *alaskensis,* Unalaska. Three views of a large bivalved lateral pedicellaria, 1 mm., ×25.

2*a*. Detached jaws, ×50.

2*b*. Crossed pedicellaria from adambulacral spinelet, ×200.

2*c*. Abactinal crossed pedicellaria, Unalaska, ×200.

2*d*. Same from St. Paul, Kodiak, 0.24 mm., ×200.

2*e*. Three abactinal spinelets, Kodiak specimen, 0.72, 0.8, 0.6 mm., ×50.

2*f*. Projection of skeleton, basal third of ray, showing irregular carinal series (*CAR–C*), broad dorsolateral area (*D*, *D*), marginals (*S*, *I*) low on side of ray, inconspicuous actinals (*AC*); *AD*, direction of disk, ×7.

3. *Leptasterias alaskensis* f. *shumaginensis,* ×25. Lateral bivalved pedicellaria, 0.63 mm. (compare with 1 and 2).

3*a*. Two jaws, ×50 (compare with 1*c*, 1*d*, 2*a*, same enlargement).

4. *Leptasterias alaskensis multispina,* Wrangell, Alaska, ×50. Two lateral pedicellariae (compare with fig. 2; but note different magnifications).

5. *Leptasterias alaskensis* f. *pribilofensis,* St. Paul, Pribilof Islands. Abactinal spinelet ×100 (twice magnification of 2*e*).

5*a*. Lateral pedicellaria, ×25 (compare with fig. 2, same enlargement).

PLATE 49

FIGURE 1. *Leptasterias camtschatica* Brandt, Medni, Commander Islands, ×1½.

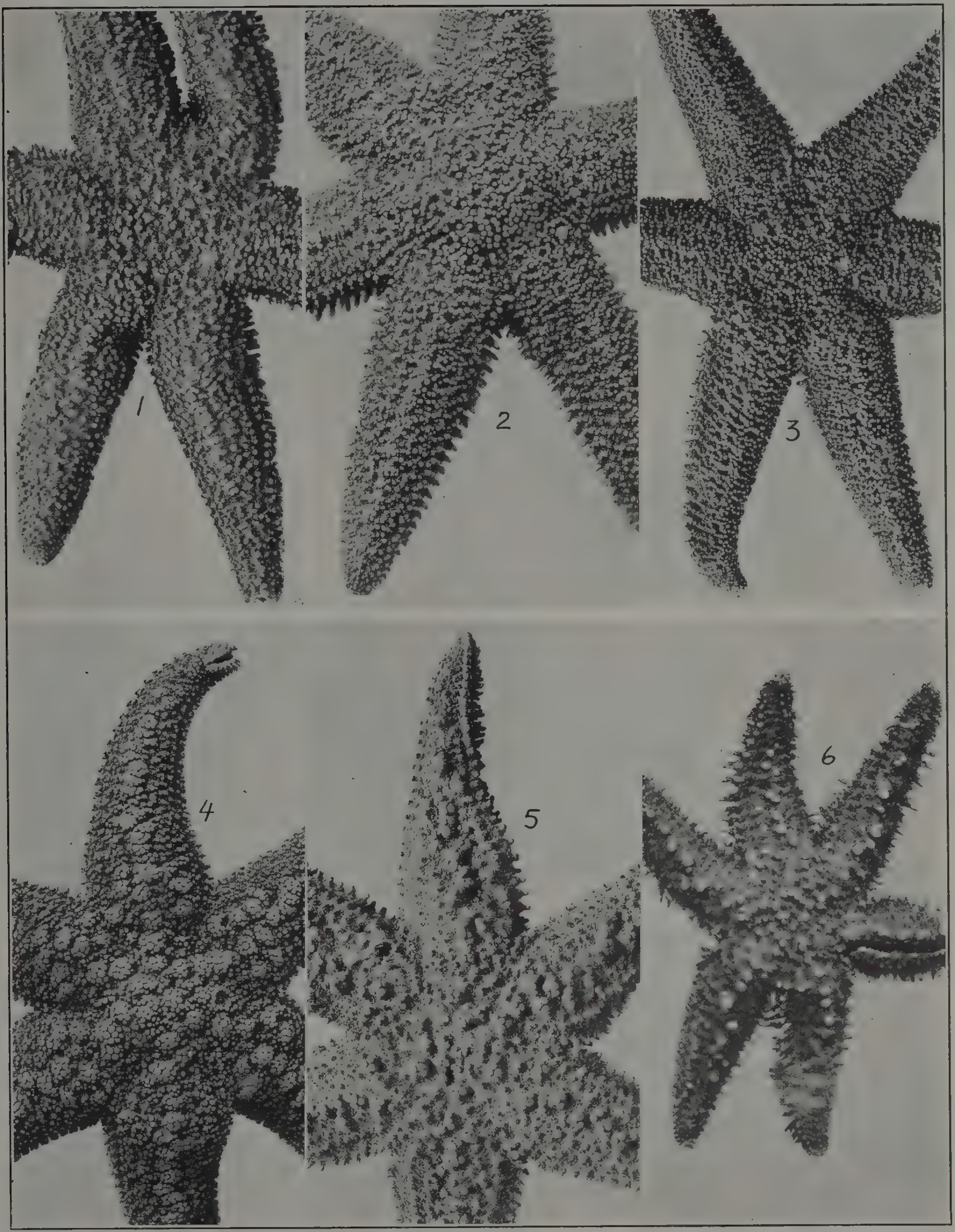
2. *Leptasterias camtschatica dispar* (Verrill) forma *nitida* Fisher, St. Paul, Pribilof Islands, ×1⅘.

3. *Leptasterias camtschatica dispar* (Verrill) forma *nesiotis* Fisher, St. Paul, Pribilof Islands, ×1⅘.

4. *Leptasterias camtschatica dispar* (Verrill) forma *nitida-dispar*, St. George Island, Pribilof Islands, ×1½.

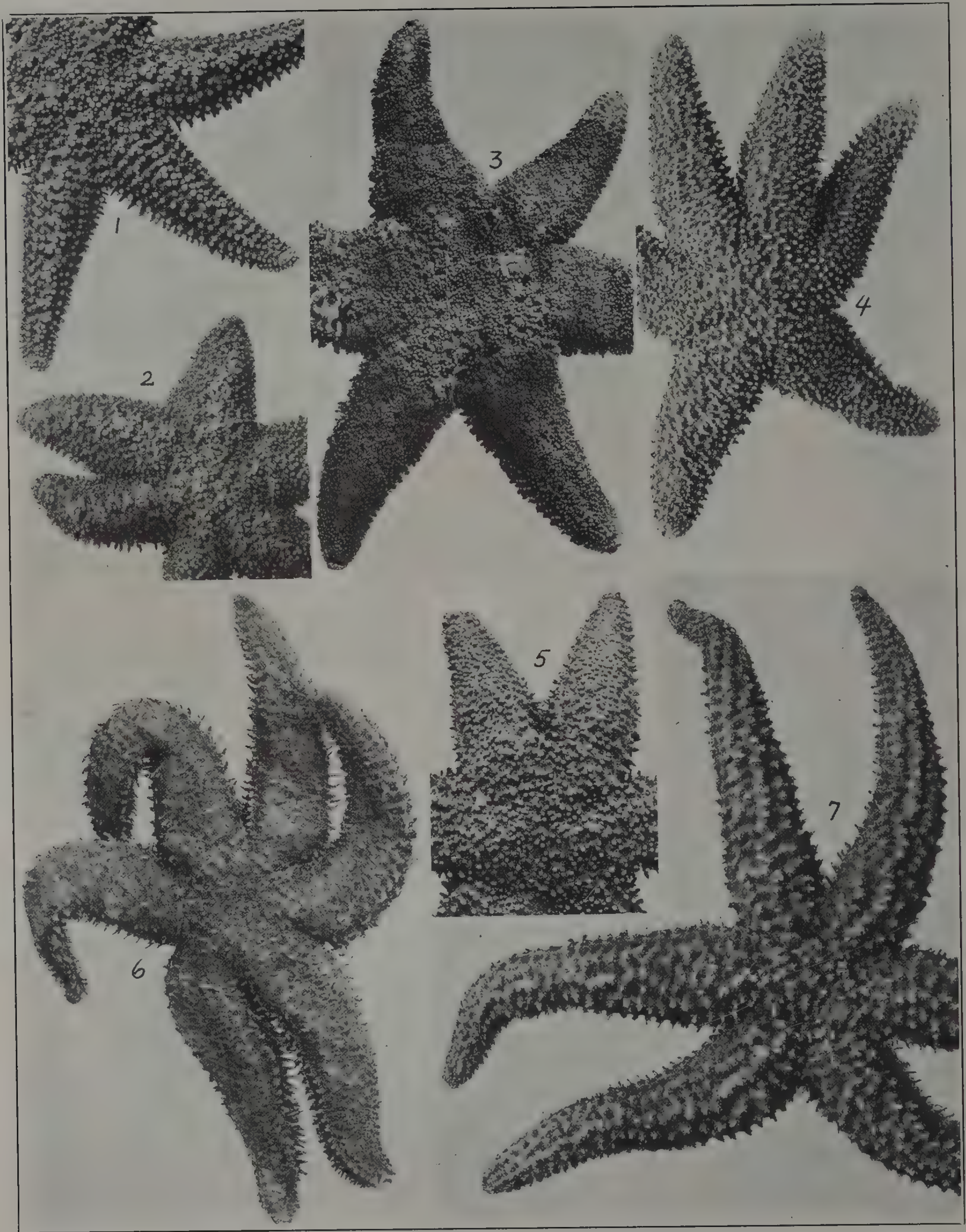
5. *Leptasterias camtschatica dispar* (Verrill) forma *dispar*, Attu, Aleutian Islands, ×1⅕.

6. *Leptasterias camtschatica dispar* (Verrill) forma *dispar*, Unalaska, Aleutian Islands, ×2.



1. Leptasterias camtschatica. 2. L. camtschatica dispar forma nitida. 3. Forma nesiotis. 4. Forma nitida-dispar. 5, 6. Forma dispar

For explanation of plate see page facing.



1. Leptasterias camtschatica dispar forma nitida. 2, 3. L. aleutica. 4, 5. L. asteira. 6. L. leptodoma
7. L. hexactis forma hexactis

For explanation of plate see page facing.

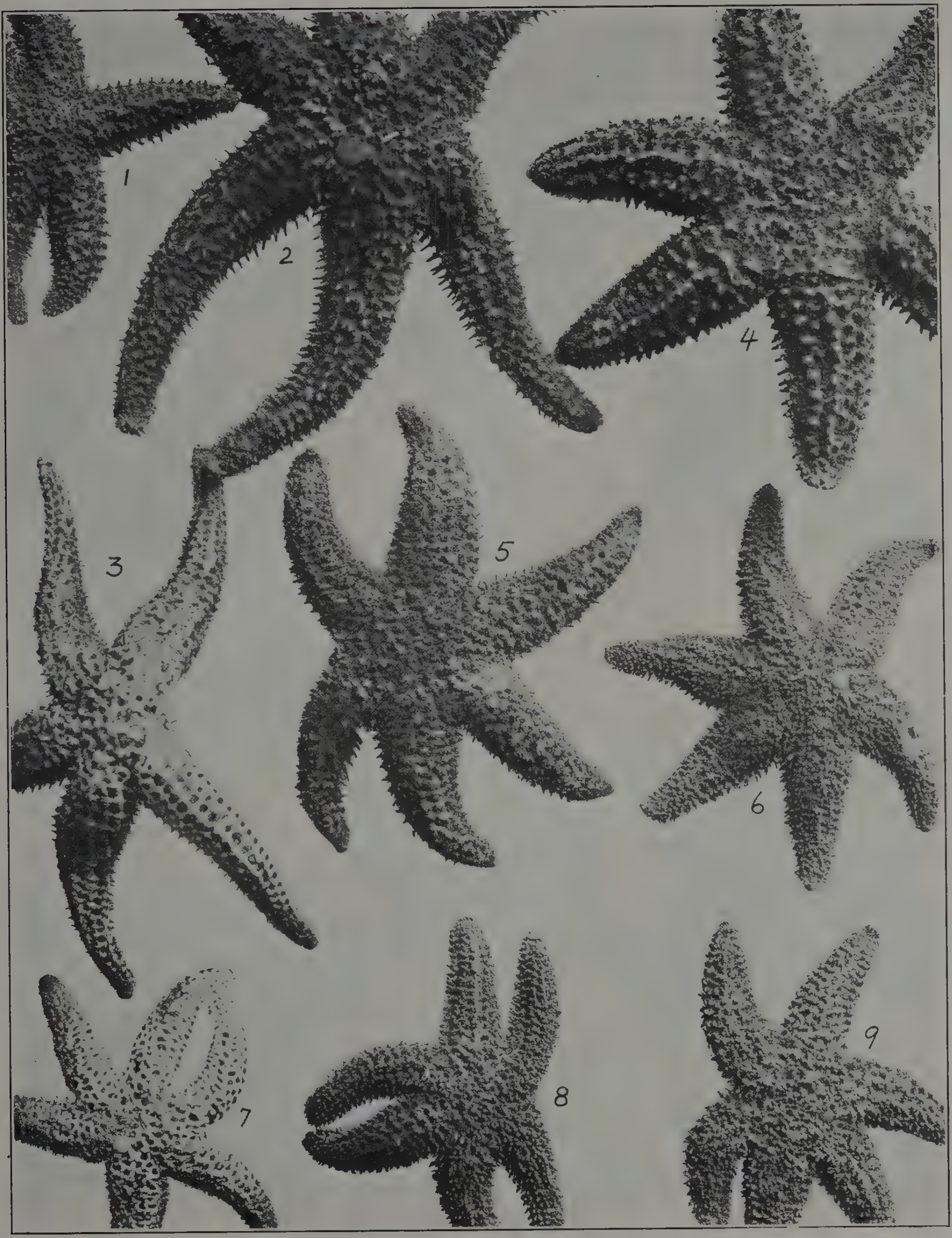
PLATE 50

FIGURE 1. *Leptasterias camtschatica dispar* forma *nitida*, Karluk, Kodiak, ×1⅘.
2. *Leptasterias aleutica*, Unalaska, ×3.
3. *Leptasterias aleutica*, type, Adakh Island, Aleutian Islands, ×2.
4. *Leptasterias asteira*, Sanborn Harbor, Nagai, Shumagin Islands, ×3.
5. *Leptasterias asteira*, Adakh, Aleutian Islands, ×3.
6. *Leptasterias leptodoma*, Atka, Aleutian Islands, ×2⅕.
7. *Leptasterias hexactis* forma *hexactis*, Orcas, San Juan Islands, Wash., ×2.

PLATE 51

With the exception of Figure 4 all specimens are from Stimpson's type series of *Leptasterias hexactis*, No. 1368, U. S. N. M.; slightly less than twice natural size

FIGURE 1. Forma *regularis*.
2. Forma *hexactis*, the type specimen.
3. Forma *hexactis*, skeleton of one arm cleaned.
4. Forma *aspera*, Alert Bay, British Columbia (not a Stimpson specimen).
5–9. Forma *plena*.



LEPTASTERIAS HEXACTIS

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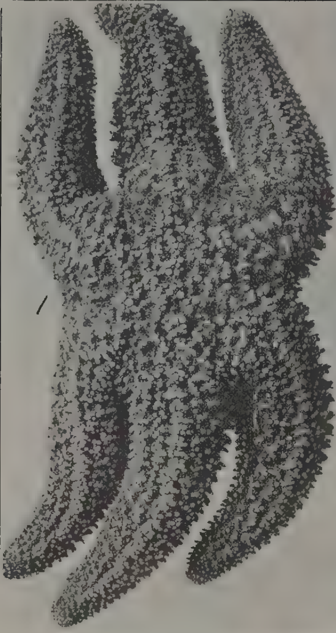

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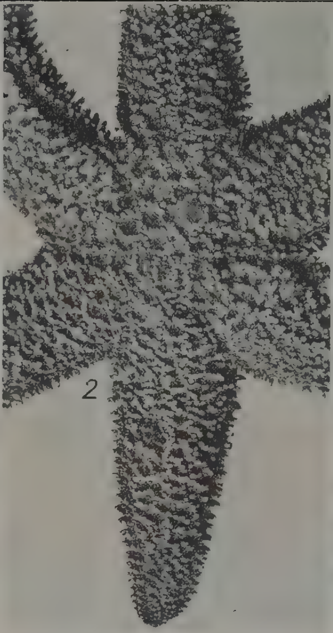

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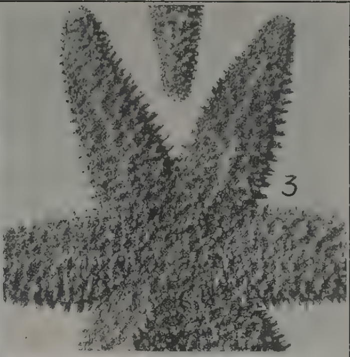

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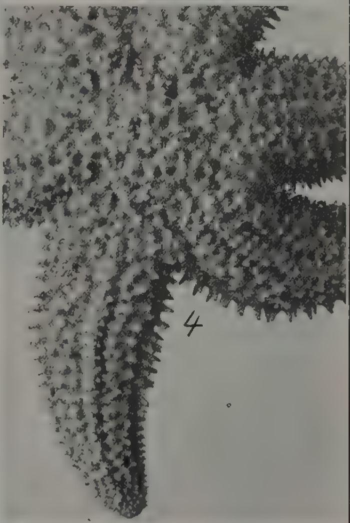

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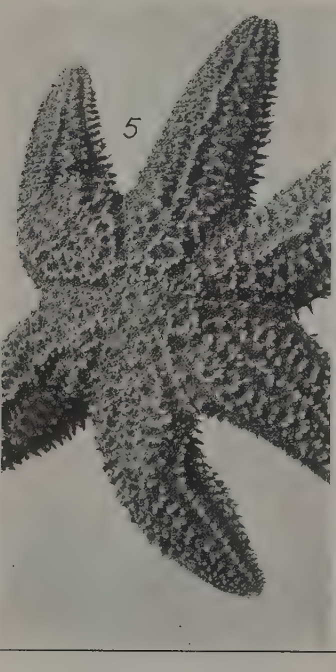

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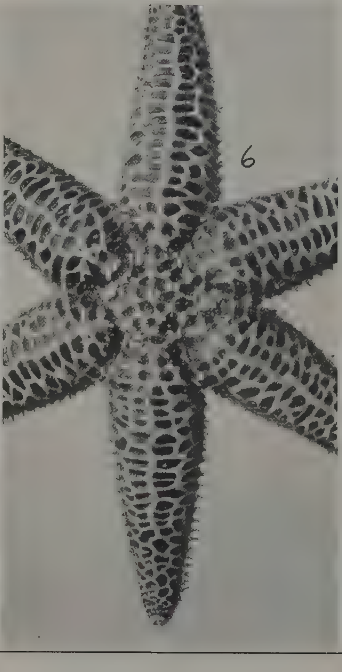

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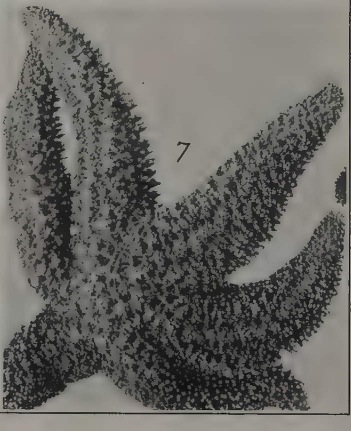


7

Leptasterias hexactis

For explanation of plate see page facing.

PLATE 52

Formae of *Leptasterias hexactis*

FIGURE 1. Forma *siderea*, Karluk, Kodiak, ×1¾.
2. Forma *siderea*, Karluk, Kodiak, ×1¾.
3. Forma *regularis*, Friday Harbor, San Juan Islands, Wash., ×1½.
4. Forma *regularis*, Cordova, Prince William Sound, Alaska, ×2.
5. Forma *aspera-regularis*, Karluk, Kodiak, ×1¾.
6. Forma *aspera*, largely denuded to show skeleton, Kukak Bay, Shelikof Strait, Alsaka, ×1⅔.
7. Forma *plena*, Forrester Island, Alaska, ×1½.

PLATE 53

Leptasterias hexactis vancouveri (Perrier) San Juan Islands, Wash. (See text for explanation of variations)

FIGURE 1. Specimen with broad carinals, groups of abactinal spinelets in longiseries, numerous superomarginal spinelets ($\mathrm{I}a^1$, b^1), ×1.1.

2. Specimen with narrower carinals ($\mathrm{I}a^1$, b^2), ×1⅖.

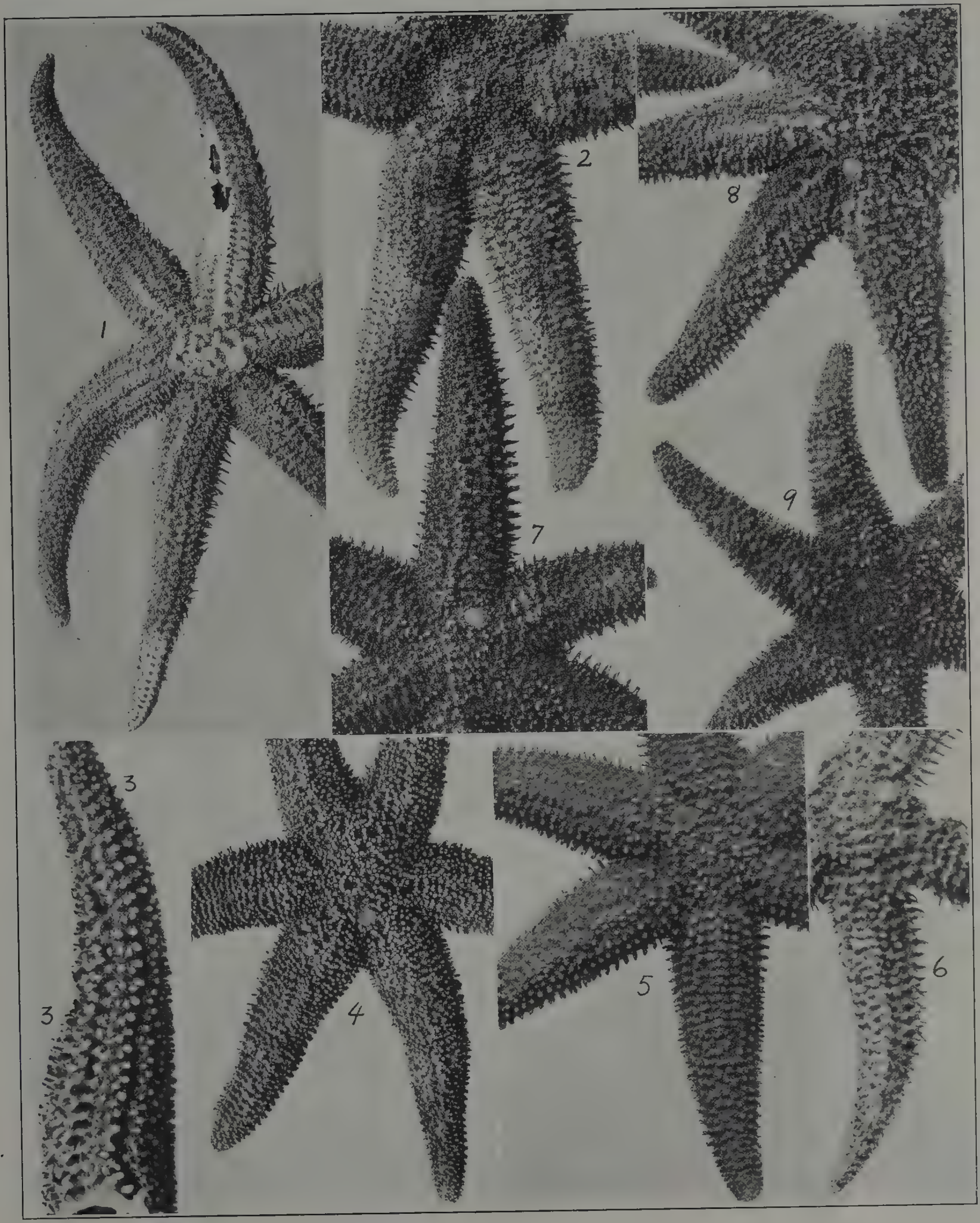
3. Side view of ray of a specimen in Class $\mathrm{I}a^1$, b^2 to show vertical combs of spinelets, ×1⅞.

4. Specimen with numerous superomarginal spinelets but groups of abactinal spinelets not in apparent longiseries ($\mathrm{I}a^2$).

5. Specimen belonging to Class II, in which the superomarginal spinelets average three; this specimen is intermediate between a^1 and a^2 and suggests *Leptasterias camtschatica*, ×1⅗.

6. Small specimen of Class III (superomarginal spinelets two, sporadically three with abactinal spinelets in longiseries (a^1), ×2.

7, 8, 9. Three specimens belonging in Class III, but with more or less irregularly arranged dorsolateral spinelets (a^2), ×1⅖.



LEPTASTERIAS HEXACTIS VANCOUVERENSIS

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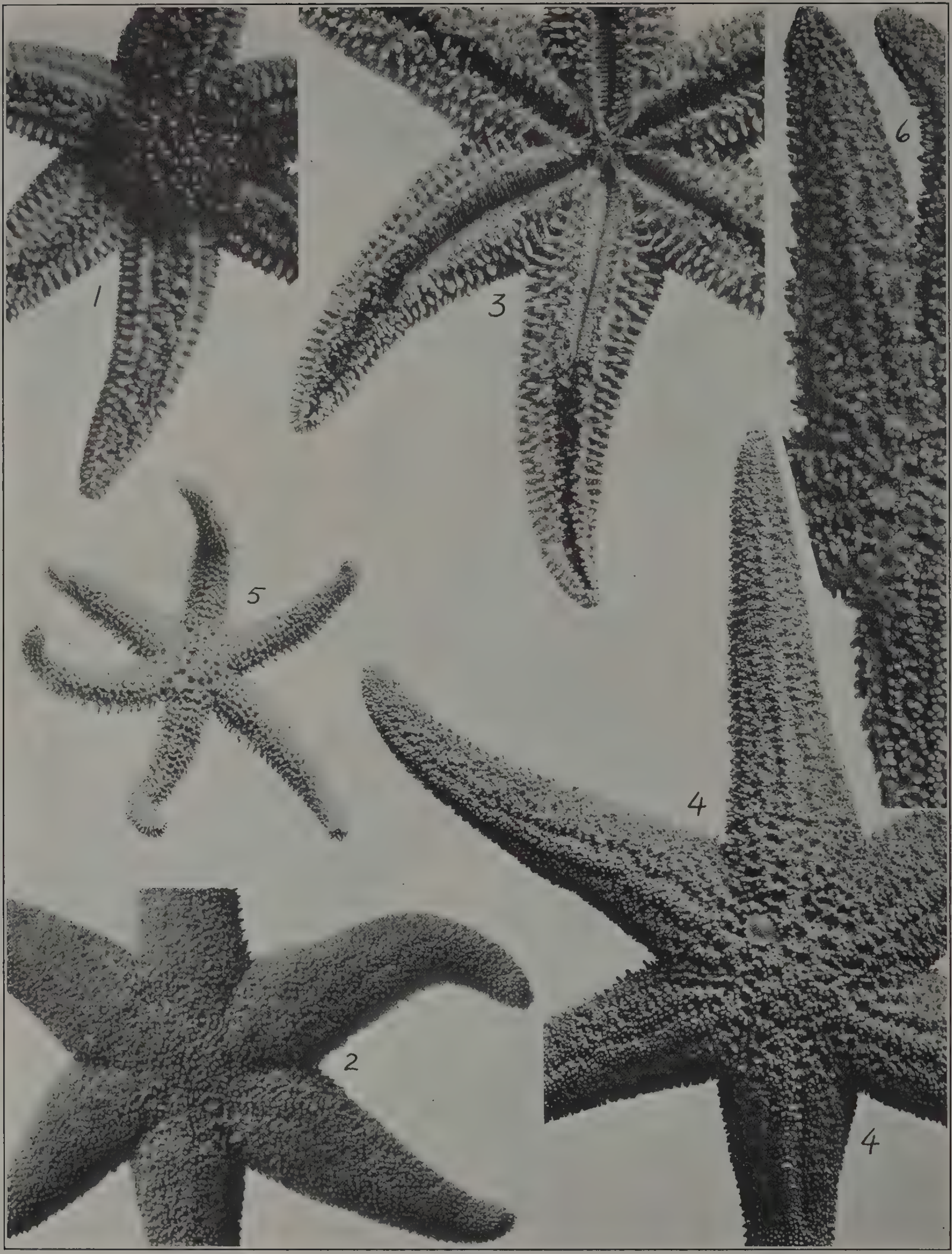


1–4. LEPTASTERIAS AEQUALIS. 5. L. PUSILLA. 6. L. HEXACTIS FORMA SIDEREA

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 54

FIGURE 1. *Leptasterias aequalis* (Stimpson); actinal view of alcoholic specimen, with eggs, Monterey Bay, Calif., ×2.

2. *Leptasterias aequalis*; abactinal view of alcoholic specimen in which the spinelets are not in evident longiseries, Monterey Bay, ×2.
3. *Leptasterias aequalis*; actinal view of dried specimen similar to Figure 4, vicinity of Monterey Bay, ×1⅘.
4. *Leptasterias aequalis*; large typical specimen, vicinity of Monterey Bay, ×1⅘.
5. *Leptasterias pusilla* Fisher; typical example, dried, for comparison with *L. aequalis*; Cypress Point near Monterey Bay, ×1⅘.
6. *Leptasterias hexactis* forma *siderea*, Middleton Island, Alaska, ×2

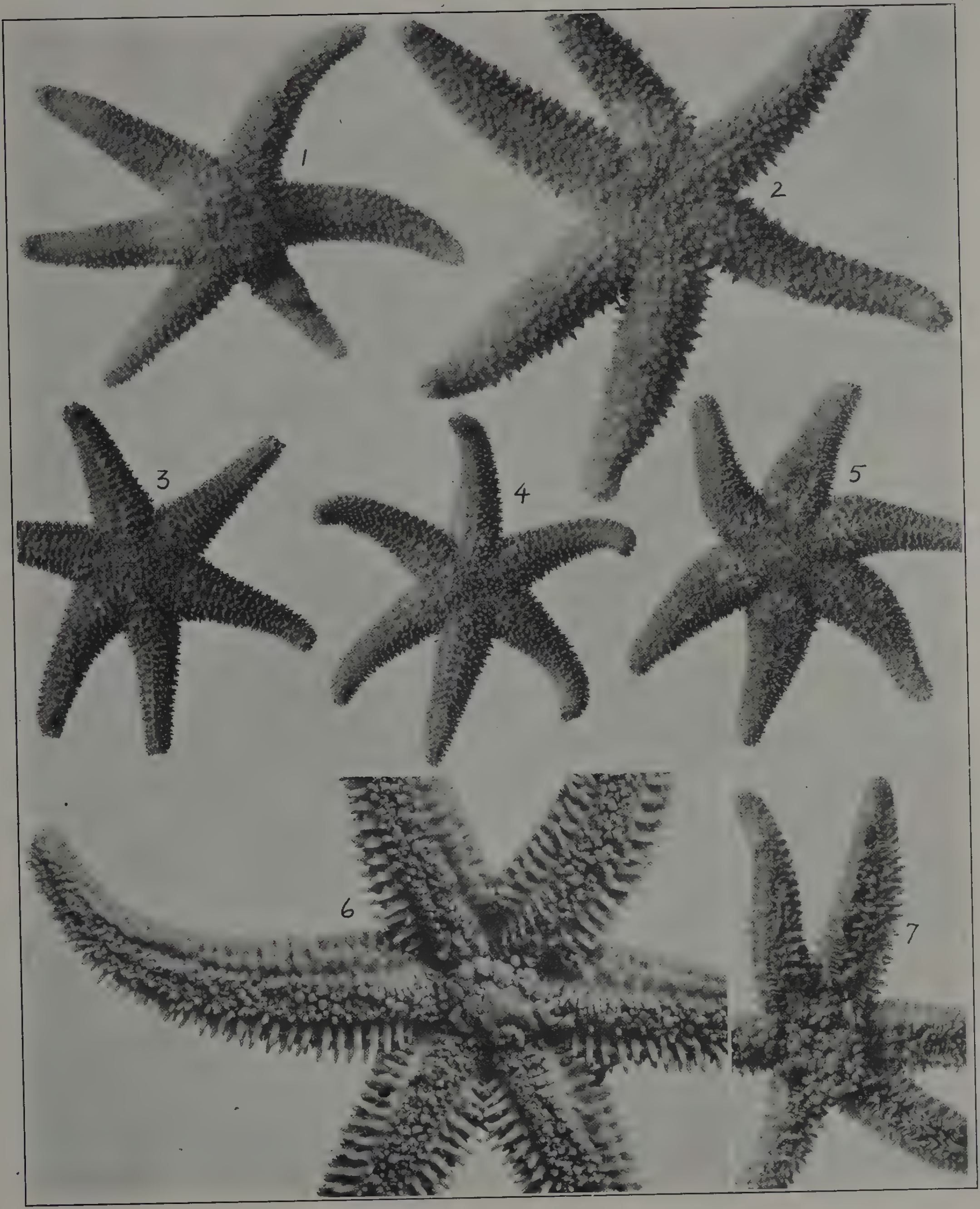
Plate 55

Figures 1, 2. *Leptasterias pusilla*, Cypress Point, vicinity of Monterey Bay, alcoholic specimen, ×3.

3, 4, 5. *Leptasterias aequalis* forma *nana*, Monterey Bay, ×3.

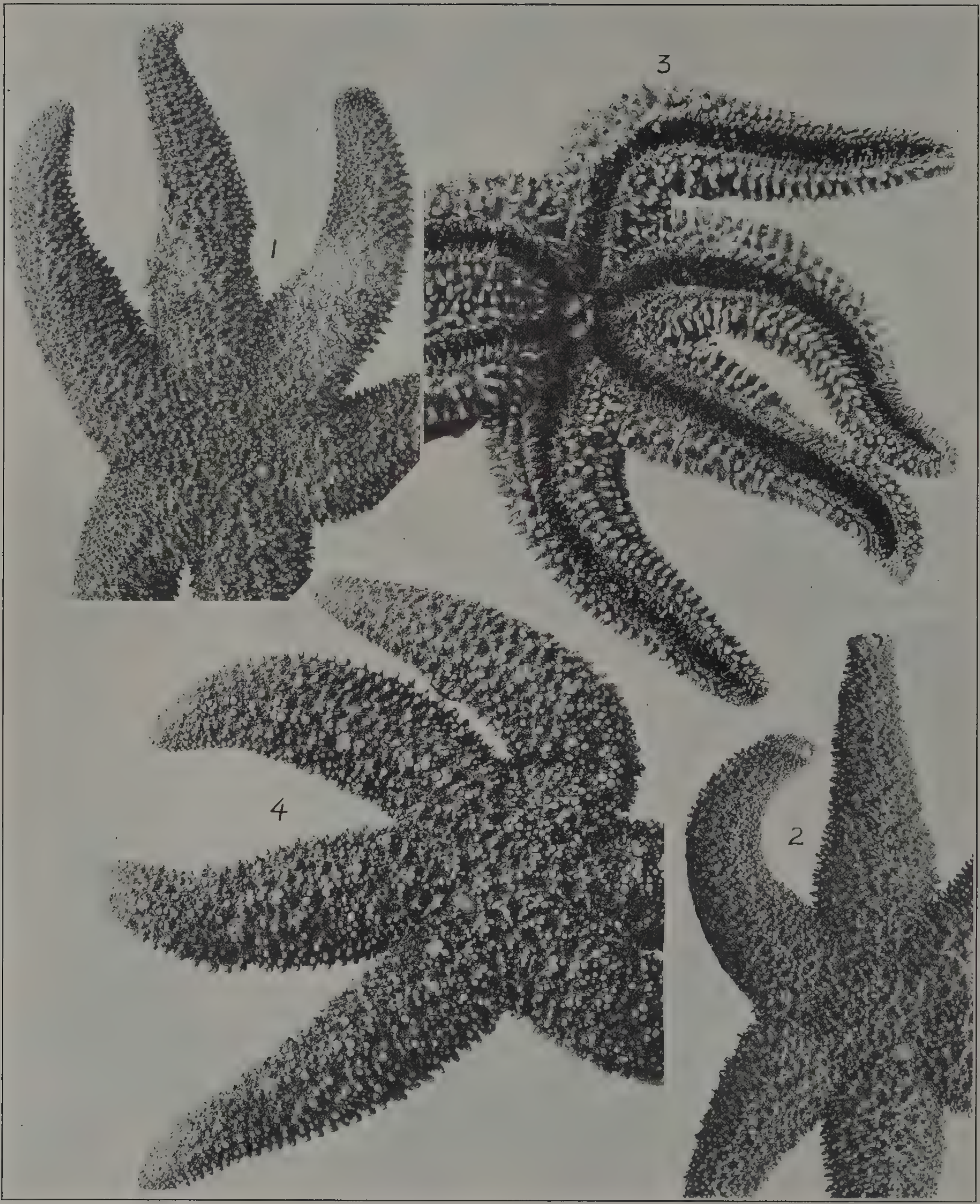
6. *Leptasterias aequalis* forma *aequalis*, Cypress Point, vicinity of Monterey Bay. Female carrying young about ready to leave. Some are attached to the partly everted stomach, ×2.

7. *Leptasterias pusilla*, Cypress Point, vicinity of Monterey Bay. Female carrying young in cluster over mouth, ×2.



1, 2, 7. Leptasterias pusilla. 3–6. L. aequalis

For explanation of plate see page facing



Leptasterias alaskensis forma alaskensis

For explanation of plate see page facing.

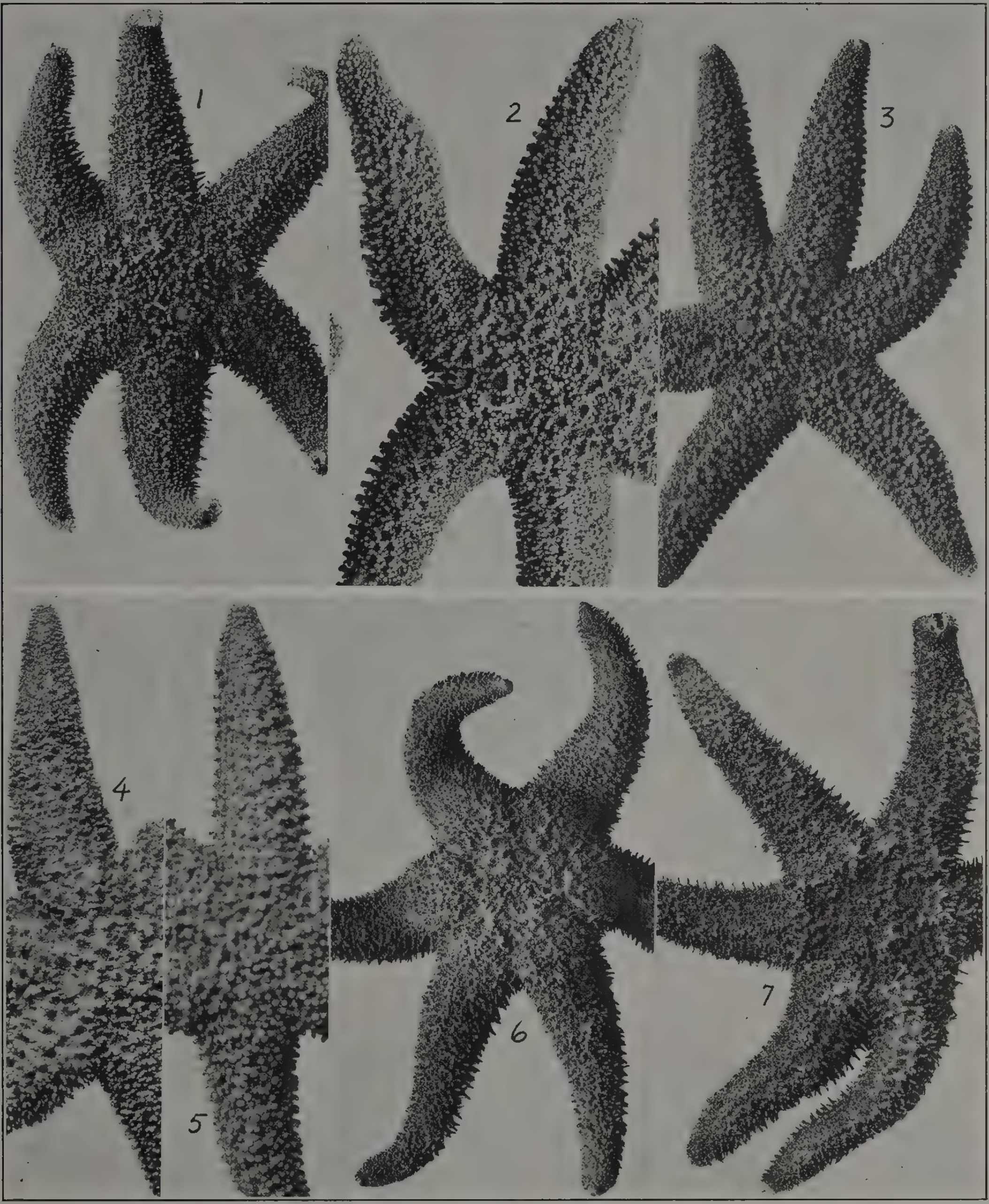
Plate 56

Leptasterias alaskensis forma *alaskensis* (Verrill)

Figure 1. Typical example from Unalaska, ×1⅓.
2. Specimen with smaller than typical bivalved pedicellariae, Karluk, Kodiak, ×1⅓.
3. Coarse spined example from Agattu, end of the Aleutian Chain, ×1⅖.
4. Specimen from Attu, end of Aleutian Chain, showing clustering of dorsal spinelets, ×1⅖. The form at end of Aleutian Islands is in some respects intermediate with *asiatica*.

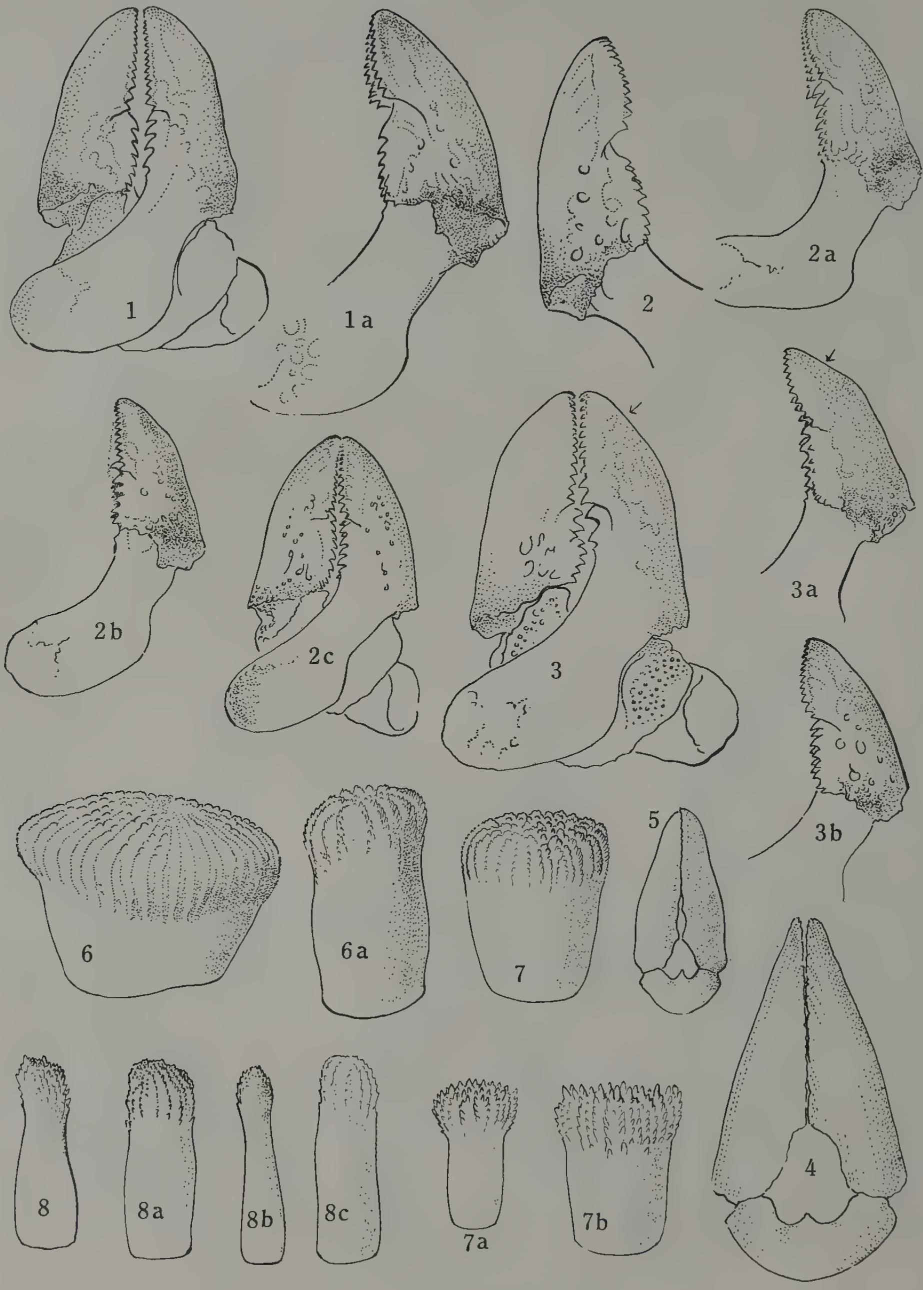
Plate 57

Figure 1. *Leptasterias alaskensis* forma *shumaginensis*, Humboldt Bay, Shumagin Islands, ×1⅖.
2. *Leptasterias alaskensis* forma *pribilofensis*, St. Paul, Pribilof Islands, ×1⅔.
3. *Leptasterias alaskensis asiatica*, type, Nikolski, Bering Island, ×1.
4. *Leptasterias alaskensis asiatica*, Nikolski, ×1⅔.
5. *Leptasterias alaskensis asiatica*, Simushir, Kuril Islands, ×1⅘.
6. *Leptasterias alaskensis multispina*, southern Alaska, ×1⅔.
7. *Leptasterias alaskensis multispina*, type, Wrangell, Alaska.



1, 2. Leptasterias alaskensis. 3–5. L. alaskensis asiatica. 6, 7. L. alaskensis multispina

For explanation of plate see page facing.


1
1a
2
2a
2b
2c
3
3a
3b
4
5
6
6a
7
7a
7b
8
8a
8b
8c

EVASTERIAS TROSCHELII

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 58

Evasterias troschelii and formae (all crossed pedicellariae are abactinal, ×200)

FIGURE 1. *Evasterias troschelii* forma *troschelii*. Pedicellaria from dorsal surface of giant specimen, Victoria, 0.27 mm. long, ×200.

1*a*. Same, abactinal pedicellaria from typical specimen (pl. 60, fig. 1) Friday Harbor, Wash., 0.28 mm., ×200.

2. Forma *alveolata*, Unalaska variety (pl. 61, fig. 2) abactinal, ×200.

2*a*. Same, coarse spined variety (pl. 62, fig. 2) Puget Sound, 0.324 mm., ×200.

2*b*. Same, small spined variety, Departure Bay, 0.225 mm., ×200.

2*c*. Same, Carmel Bay, Calif., multispinous variety, 0.24 mm., ×200.

3. Forma *acanthostoma*, typical, Unalaska (pl. 64, fig. 3), 0.30 mm., ×200.

3*a*. Same, Tongass, Alaska, variety (pl. 64, fig. 2), ×200.

3*b*. Same, from large Victoria specimen, 0.225 mm. (Pl. 65, fig. 2.)

4. Forma *troschelii*, ordinary intermarginal straight pedicellaria, giant specimen, Victoria (pl. 61, fig. 1), ×100.

5. Forma *alveolata*, actinal straight pedicellaria, Carmel Bay, Calif., ×50.

6, 6*a*. Forma *troschelii* (pl. 60, fig. 2), two abactinal spines, ×25.

7. Forma *alveolata*, Departure Bay, abactinal spine, ×25.

7*a*, 7*b*. Same, Carmel Bay, Calif., abactinal spines, ×25.

8, 8*a*, 8*b*. Forma *acanthostoma*, Unalaska, abactinal spines, ×25.

8*c*. Same, Victoria, British Columbia.

PLATE 59

FIGURE 1. *Evasterias troschelii* forma *alveolata*; part of actinostomial ring, showing odontophore (*O*), mouth plates (*M*), and first ambulacrals (*A*), ×10.

1*a*. Same, mouth plates and adjacent ambulacrals, ×20.

2. *Evasterias echinosoma;* side view of mouth plates, showing three marginal spines (usually two), and relative size of two straight pedicellariae, ×5.

2*a*–2*c*. Same, straight pedicellariae; 2*a*, from intermarginal channel, 1.1 mm., ×50; 2*b*, type, actinal interradial channel, 1.5 mm.; 2*c*, type, base of ray, intermarginal channel.

2*d*. Type, abactinal 0.09 to 1 mm.

2*e*. One jaw of 2*d*.

2*f*. An adambulacral straight pedicellaria, ×25.

2*g*. Same, an abactinal crossed pedicellaria, 0.27 to 0.3 mm., ×100.

2*h*. An adambulacral crossed pedicellaria, 0.38 mm.

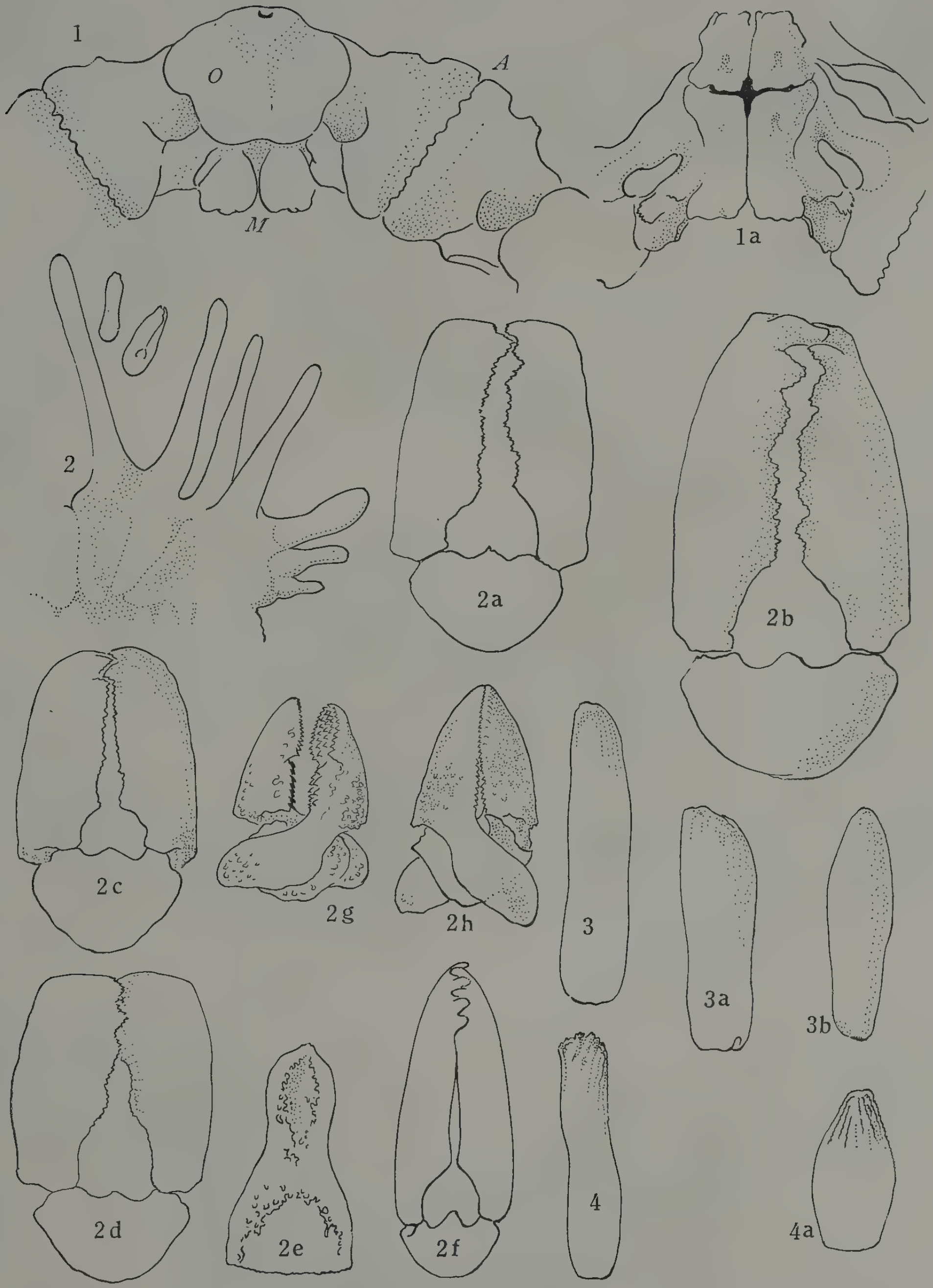
3. *Evasterias troschelii* forma *troschelii;* large specimen from Victoria, actinal spine, ×10.

3*a*. Inferomarginal spine.

3*b*. Forma *acanthostoma*, actinal spine, ×10.

4. *Evasterias echinosoma*, actinal spine, ×10.

4*a*. Same, abactinal spine, ×10.


1
O
A
M
1a
2
2a
2b
2c
2g
2h
3
3a
3b
2d
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2f
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4a

1, 3. EVASTERIAS TROSCHELII. 2, 4. E. ECHINOSOMA

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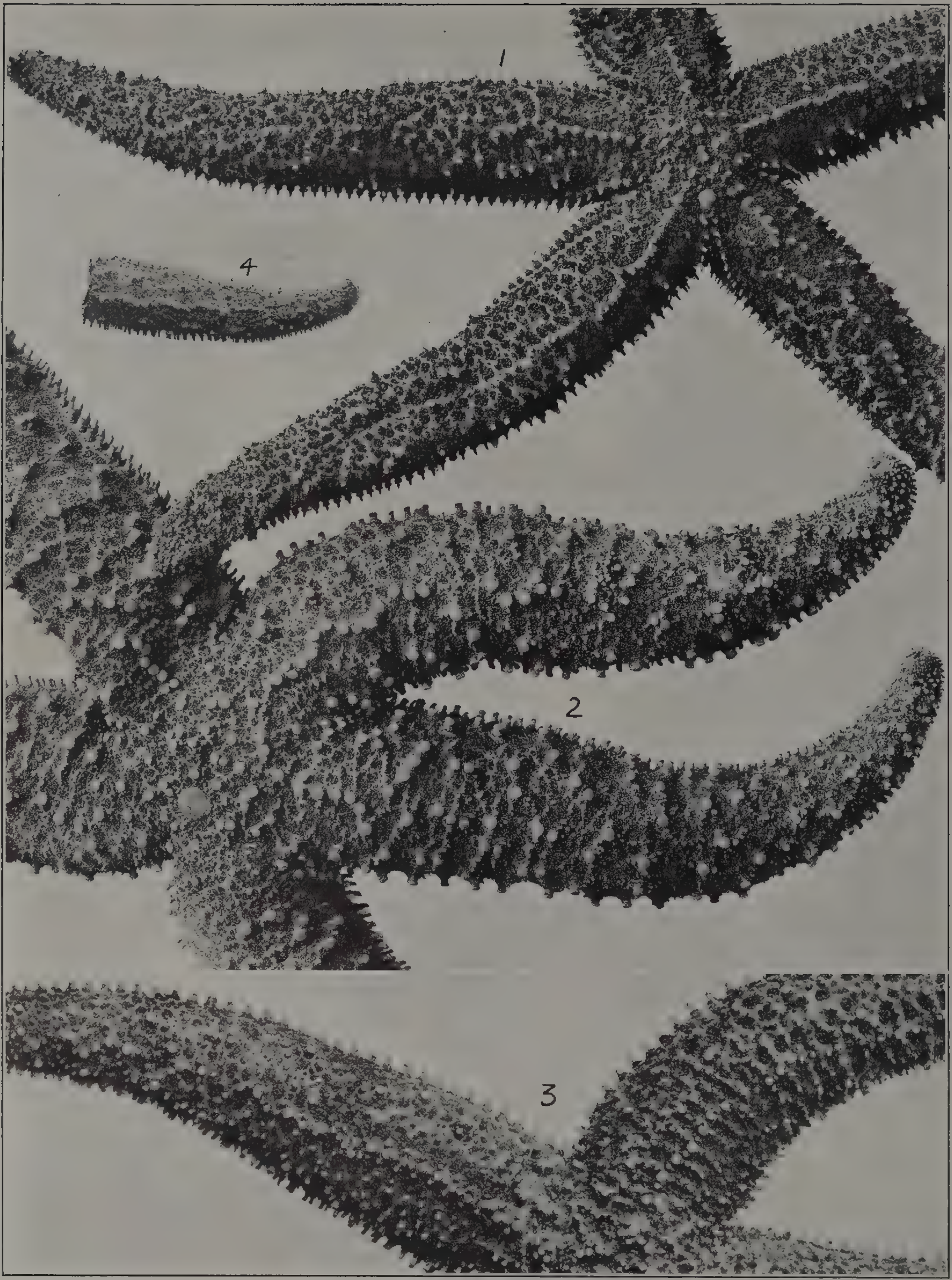


Evasterias troschelii

For explanation of plate see page facing.

Plate 60

Evasterias troschelii forma *troschelii*

Figure 1. Slender rayed variety with very slender secondary spinelets, Friday Harbor, San Juan Islands, Wash., ×1.

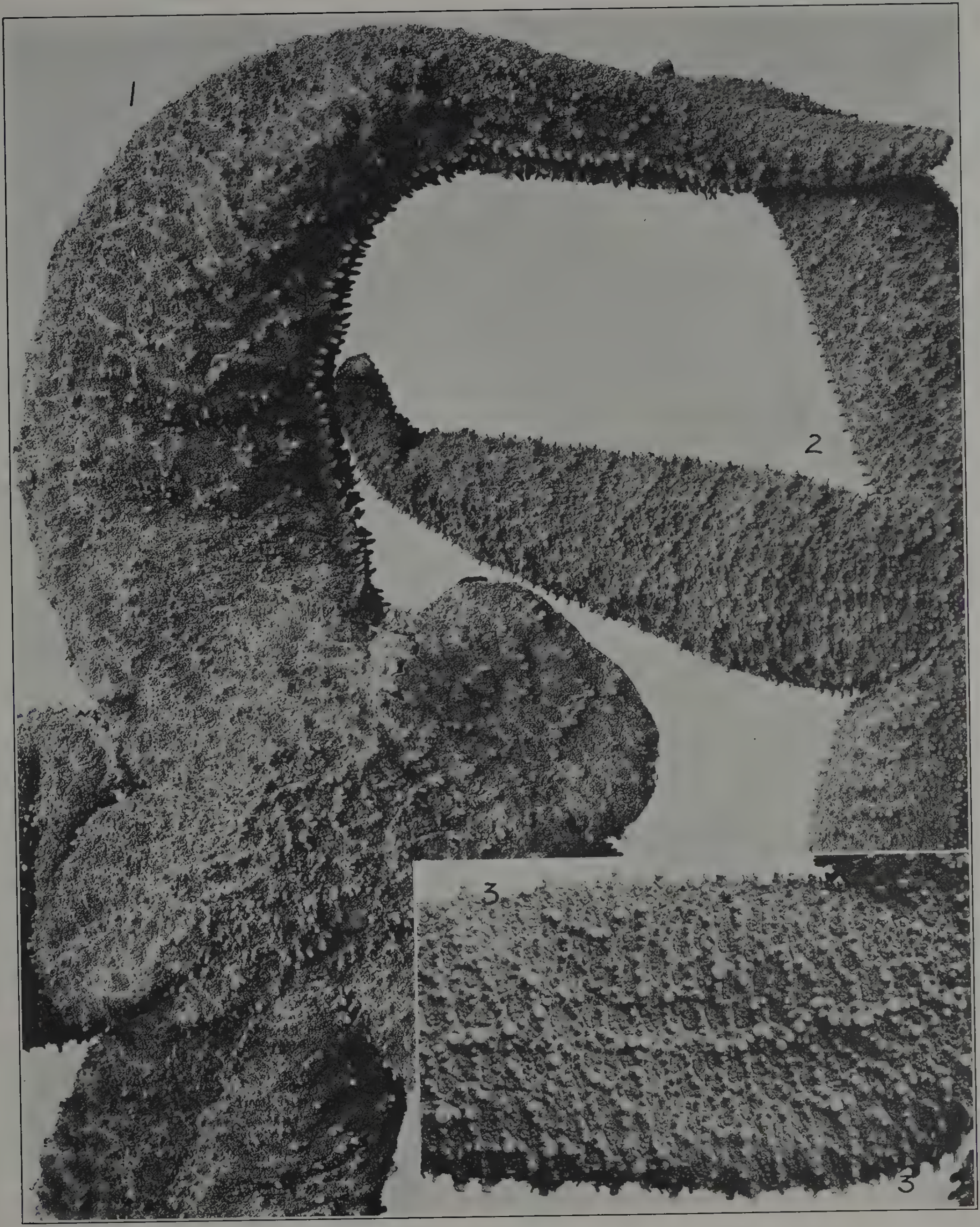
2. Variety with unusually stout primary spines. This is similar to Verrill's "*Asterias victoriana*," Friday Harbor, ×1.
3. Variety intermediate with forma *alveolata*, Orcas, San Juan Islands, Wash., ×2½.
4. Type specimen, U. S. Nat. Mus.

PLATE 61

FIGURE 1. *Evasterias troschelii* forma *troschelii,* Victoria, British Columbia, natural size; a giant individual. This is an example of Verrill's variety *rudis.* The peculiarities are largely due to age.

2. *Evasterias troschelii* forma *alveolata,* Unalaska (No. 3391) natural size. A subforma showing the very unequal dorsal spines of forma *troschelii* and the reticulate arrangement of *alveolata.*

3. *Evasterias troschelii* forma *alveolata,* Naha Bay, Alaska, ×2.



EVASTERIAS TROSCHELII

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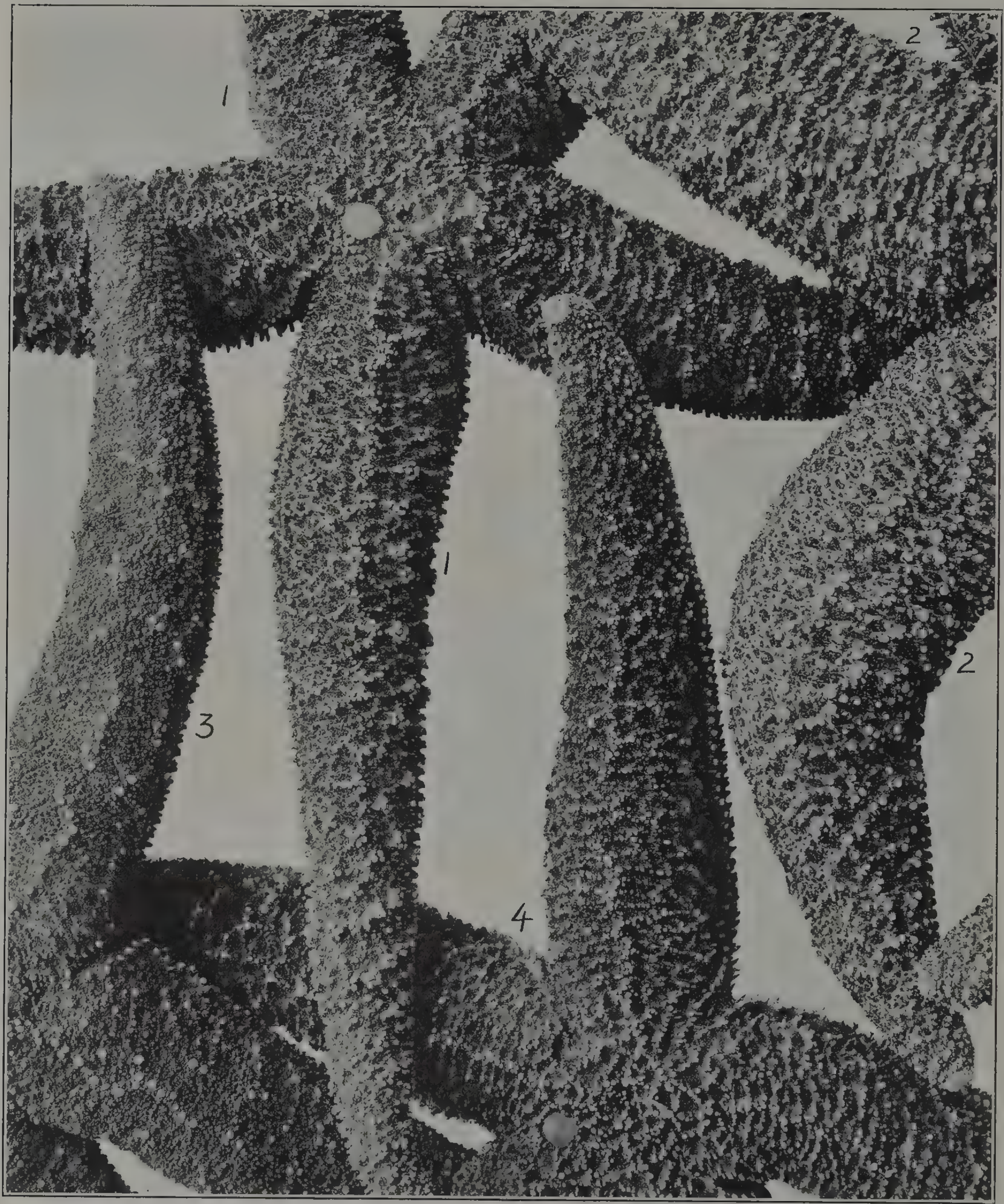


EVASTERIAS TROSCHELII FORMA ALVEOLATA

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 62

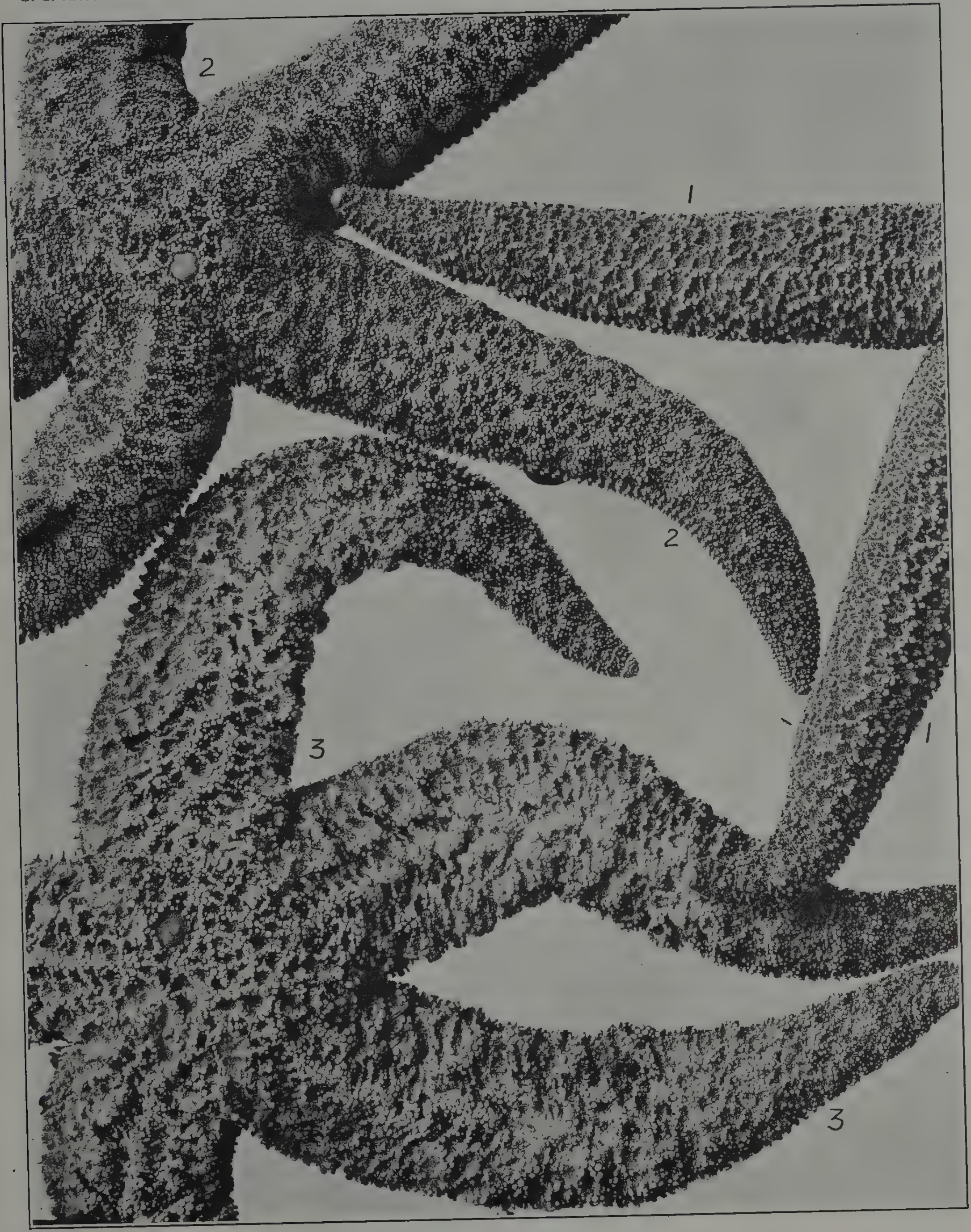
Evasterias troschelii forma *alveolata* ×1⅓

FIGURE 1. "Acervate" variety, Union Bay, British Columbia.
2. Stout rayed variety, from Puget Sound, near Tacoma, in which there is great disparity in the size of the dorsal spines.
3. The variety predominating at Unalaska.
4. Typical specimen with a few spines enlarged and with a well-developed dorsal recticulum, Orcas, San Juan Islands, Wash.

PLATE 63

Evasterias troschelii forma *alveolata*, ×1¼

FIGURE 1. Typical specimen from Departure Bay, British Columbia.
2. The multispinous subforma, Tongass, Alaska.
3. The same variation with coarser spines, Fort Rupert, British Columbia.



EVASTERIAS TROSCHELII FORMA ALVEOLATA

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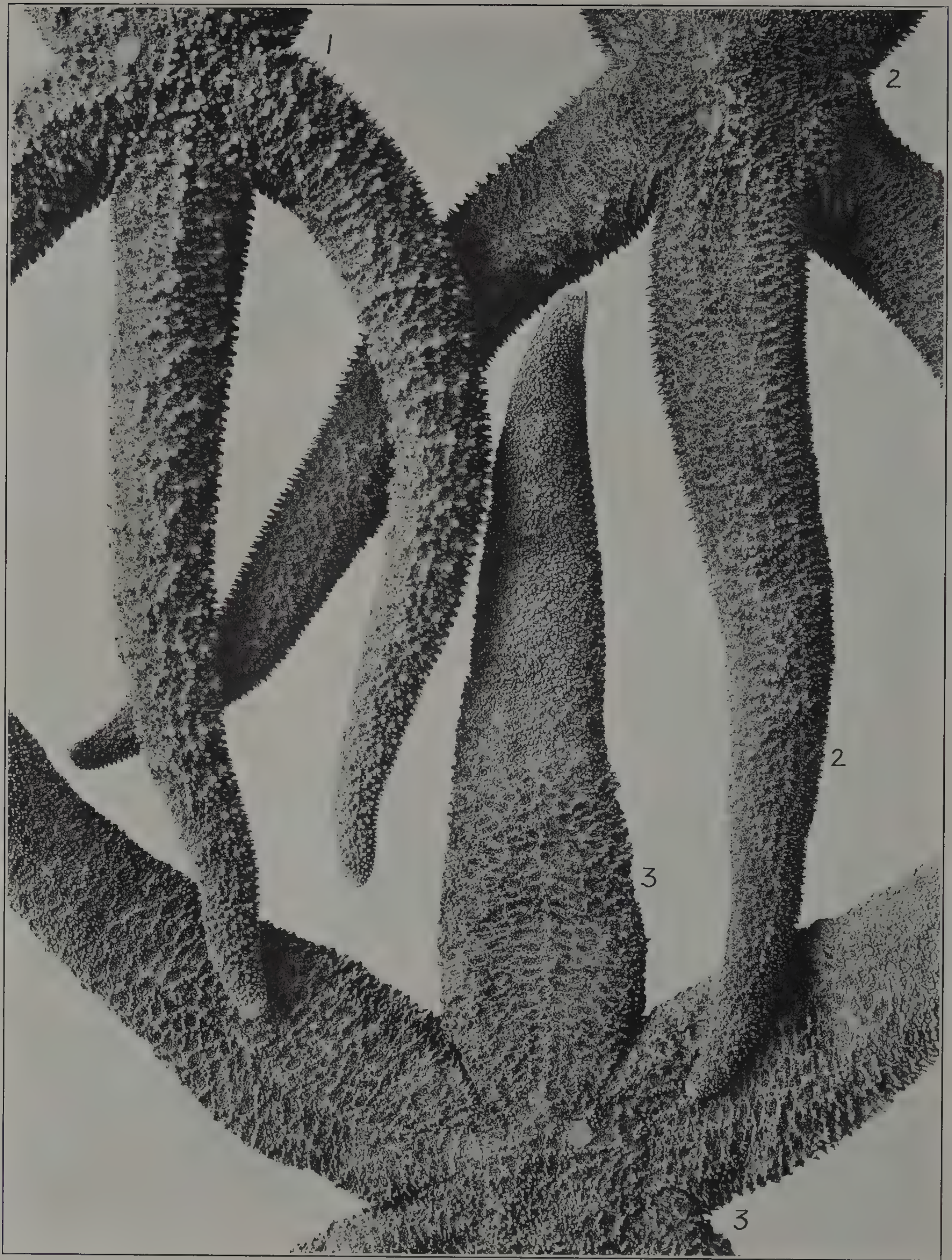


EVASTERIAS TROSCHELII

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 64

FIGURE 1. *Evasterias troschelii* forma *troschelii,* Friday Harbor, San Juan Islands, Wash., natural size.

2. *Evasterias troschelii* forma *acanthostoma,* Tongass, Alaska, natural size.

3. *Evasterias troschelii* forma *acanthostoma,* typical example from Unalaska, natural size.

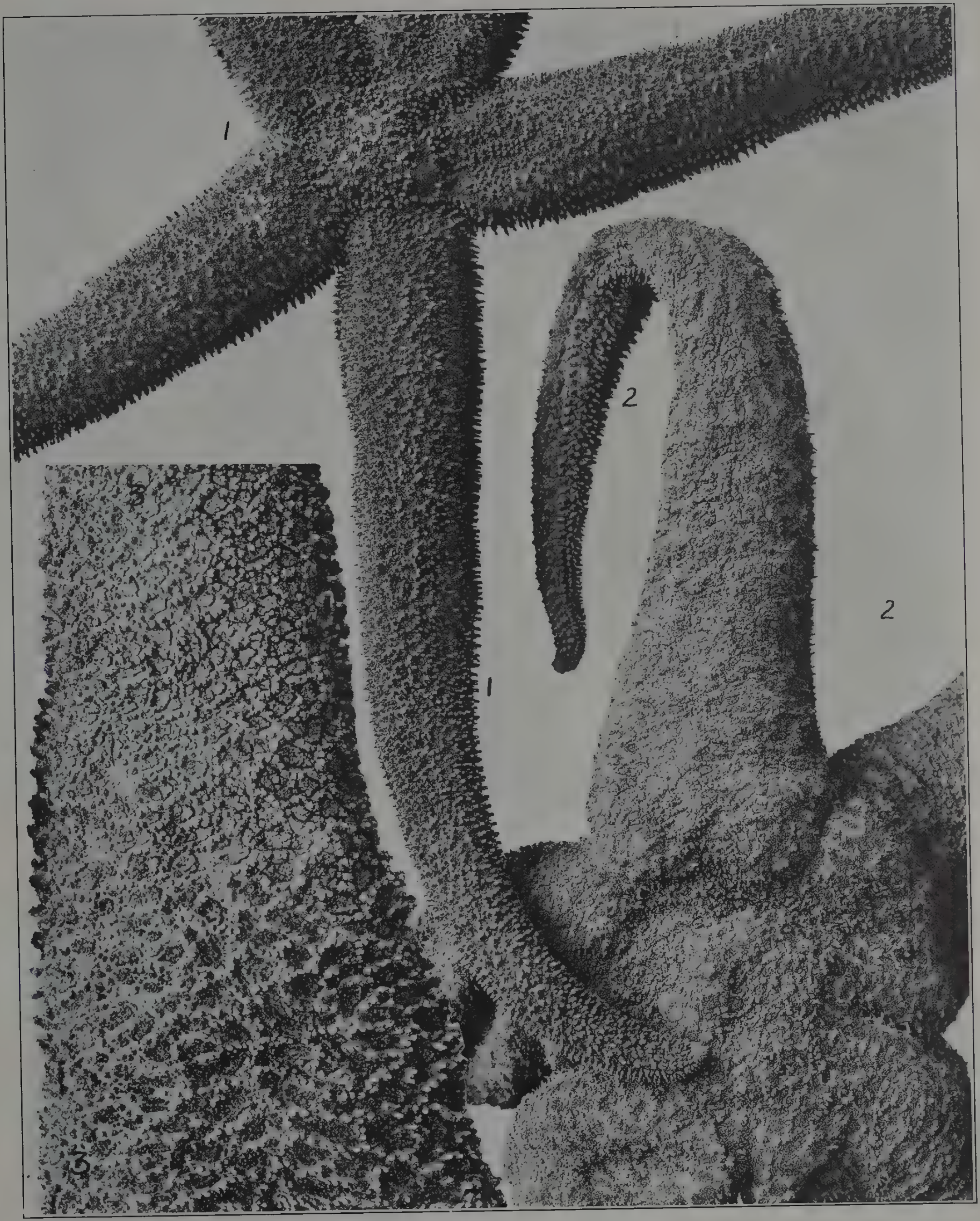
Plate 65

Evasterias troschelii forma *acanthostoma*

Figure 1. A very slender rayed variety from Orcas, San Juan Islands, Wash., ×⅚.

2. Variety with heavy rays from Victoria, British Columbia, apparently occurring with the similar giant form of *troschelii*, ×⅚.

3. Unalaska, ×2¼.



EVASTERIAS TROSCHELII FORMA ACANTHOSTOMA

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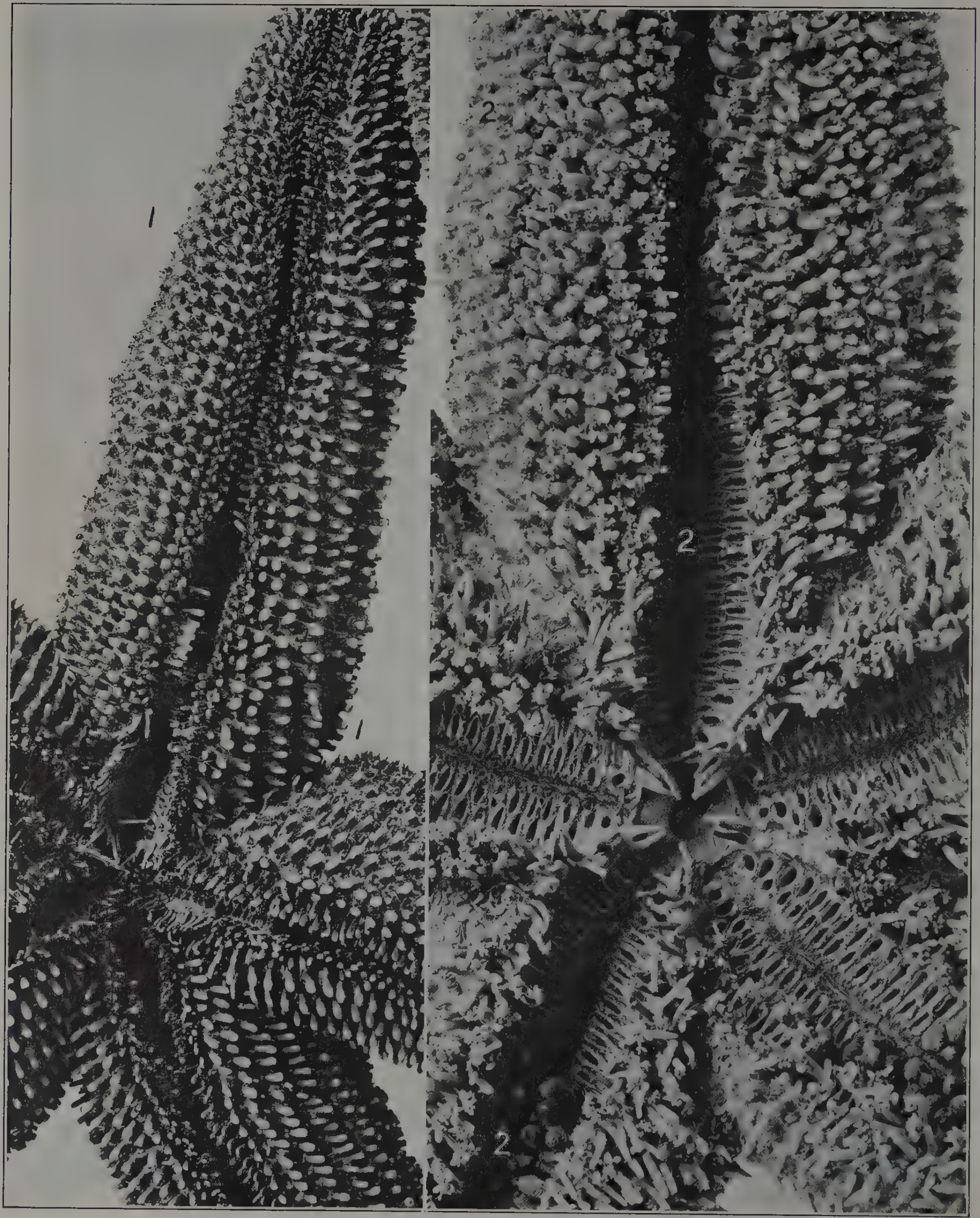


1. EVASTERIAS TROSCHELII FORMA ALVEOLATA. 2. FORMA ACANTHOSTOMA

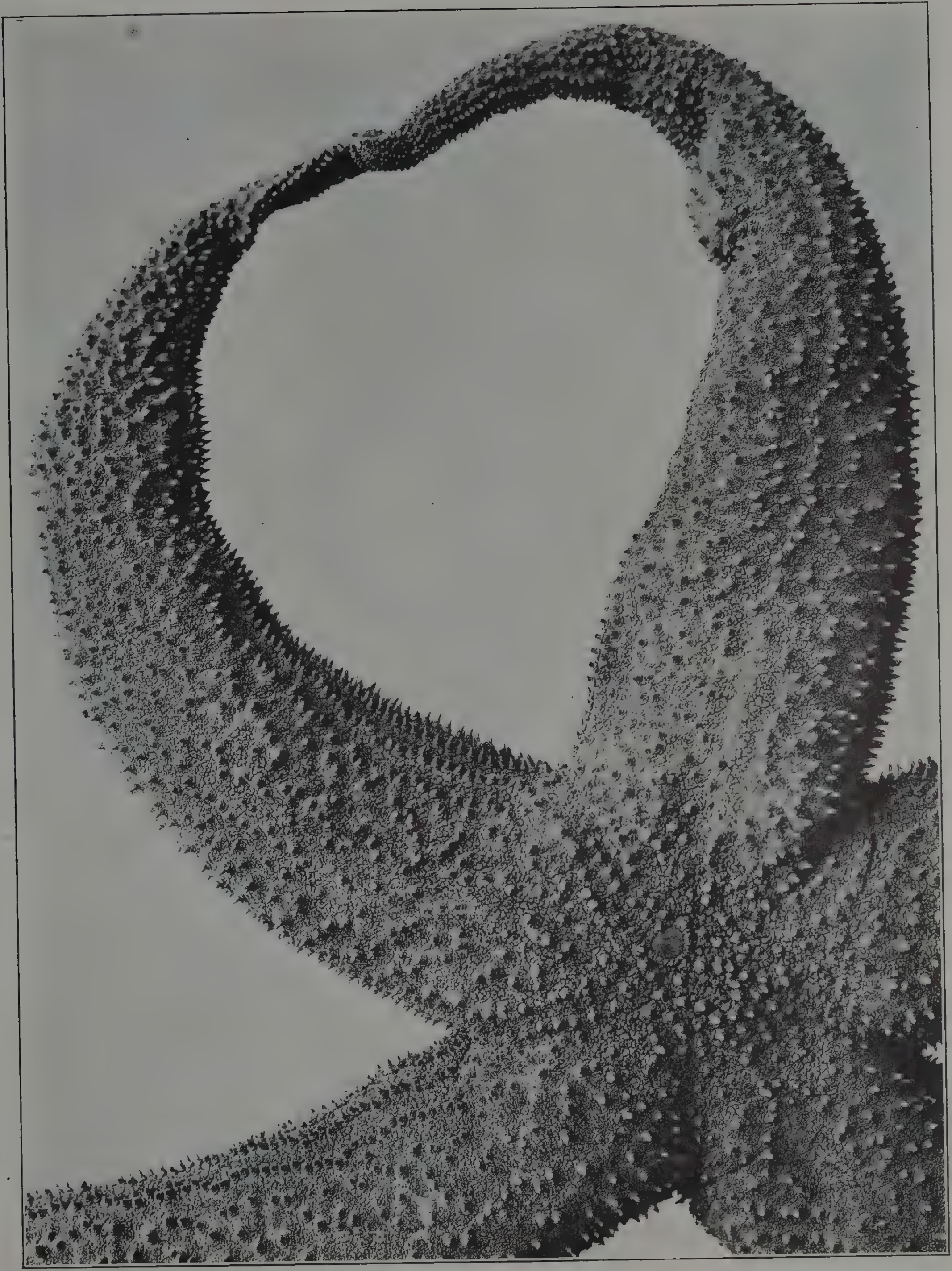
FOR EXPLANATION OF PLATE SEE PAGE FACING

PLATE 66

FIGURE 1. *Evasterias troschelii* forma *alveolata*, Unalaska, actinal surface, ×1⅓.
2. *Evasterias troschelii* forma *acanthostoma*, Unalaska, actinal surface, ×2¼.

PLATE 67

Evasterias echinosoma, type, × ¾



EVASTERIAS ECHINOSOMA

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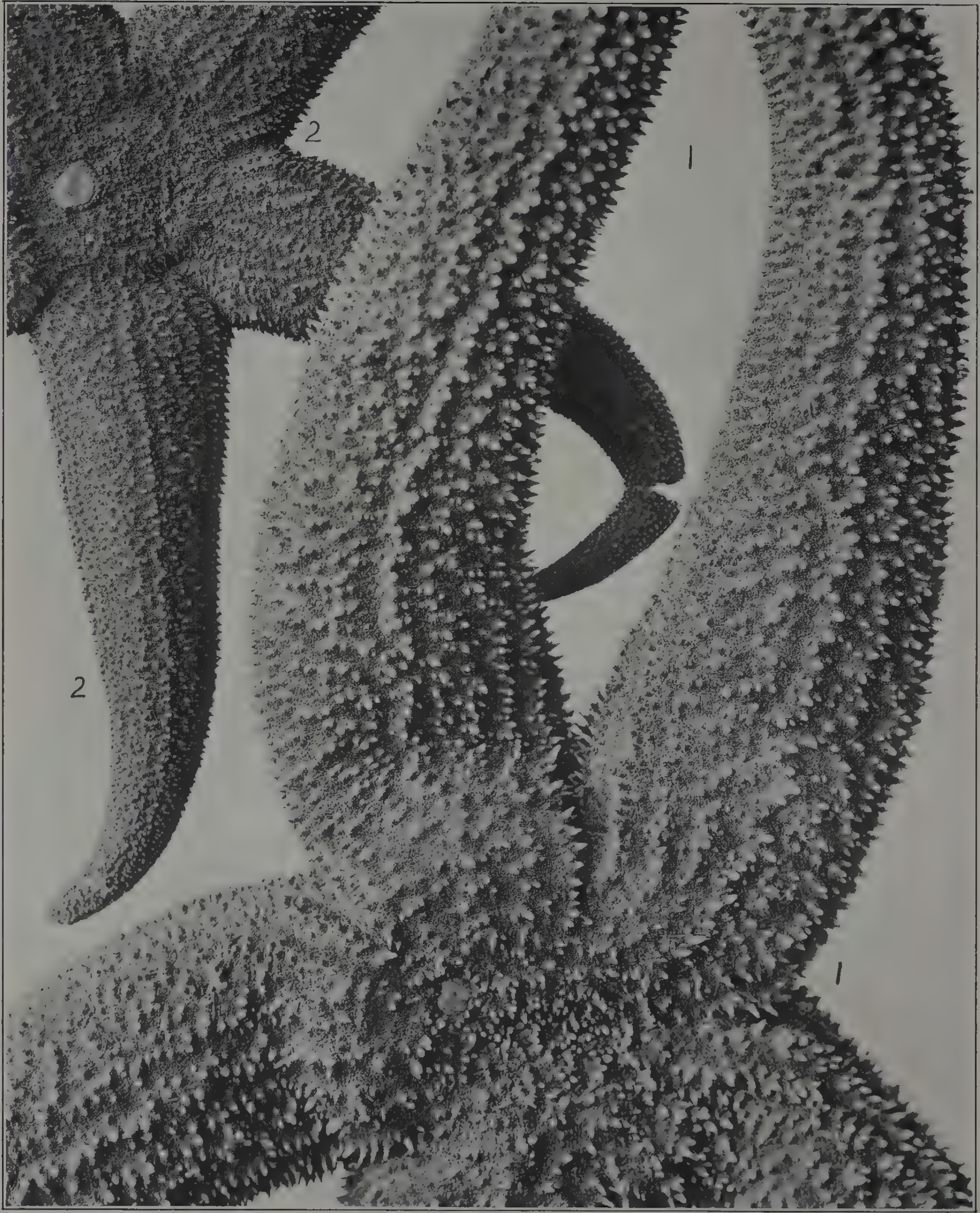


Evasterias echinosoma

For explanation of plate see page facing.

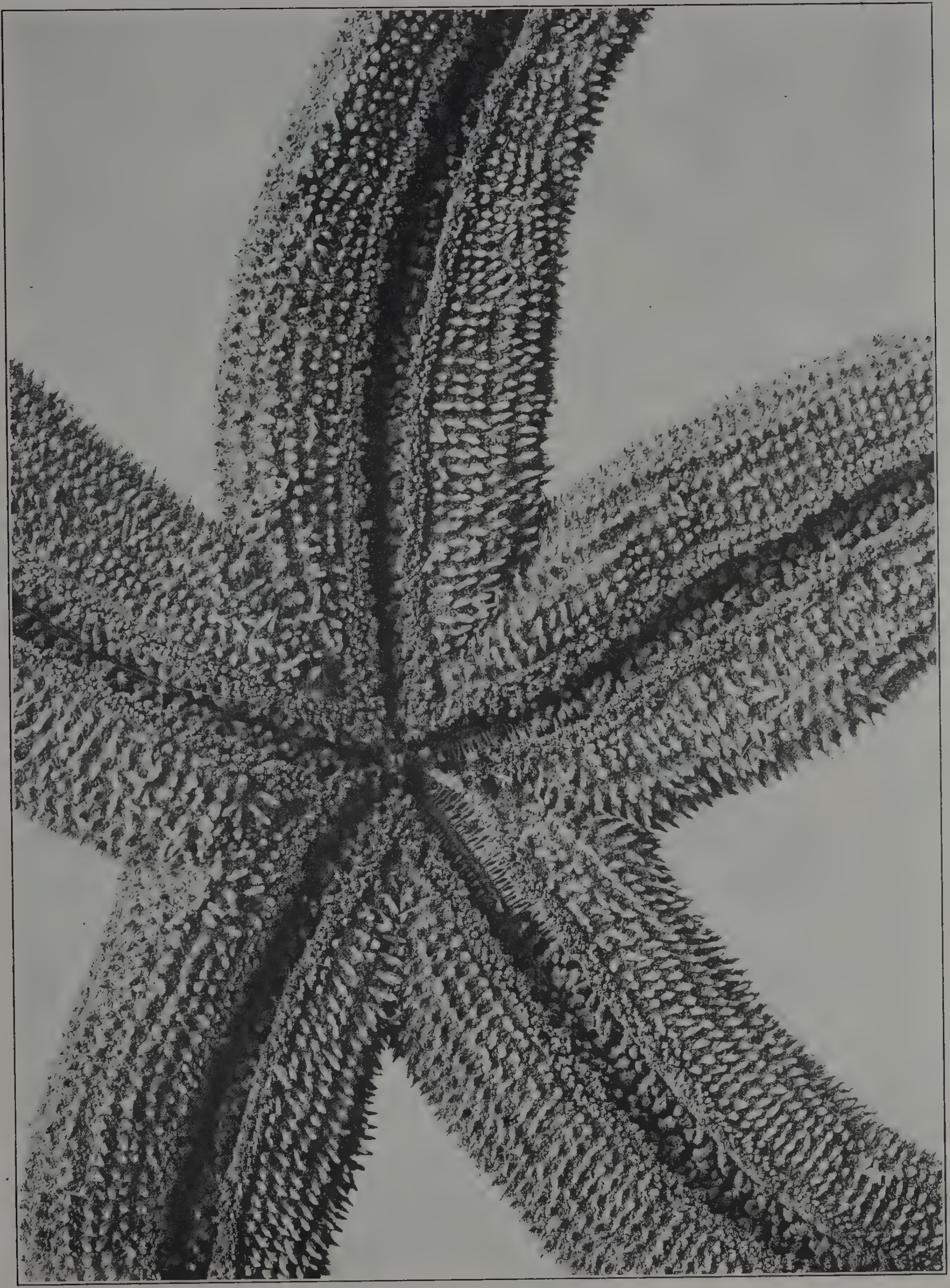
PLATE 68

Evasterias echinosoma, natural size

FIGURE 1. Large specimen from Kamchatka, station 4796.
2. Example from station 3291.

PLATE 69

Evasterias echinosoma, actinal surface of type, station 3278, natural size



EVASTERIAS ECHINOSOMA

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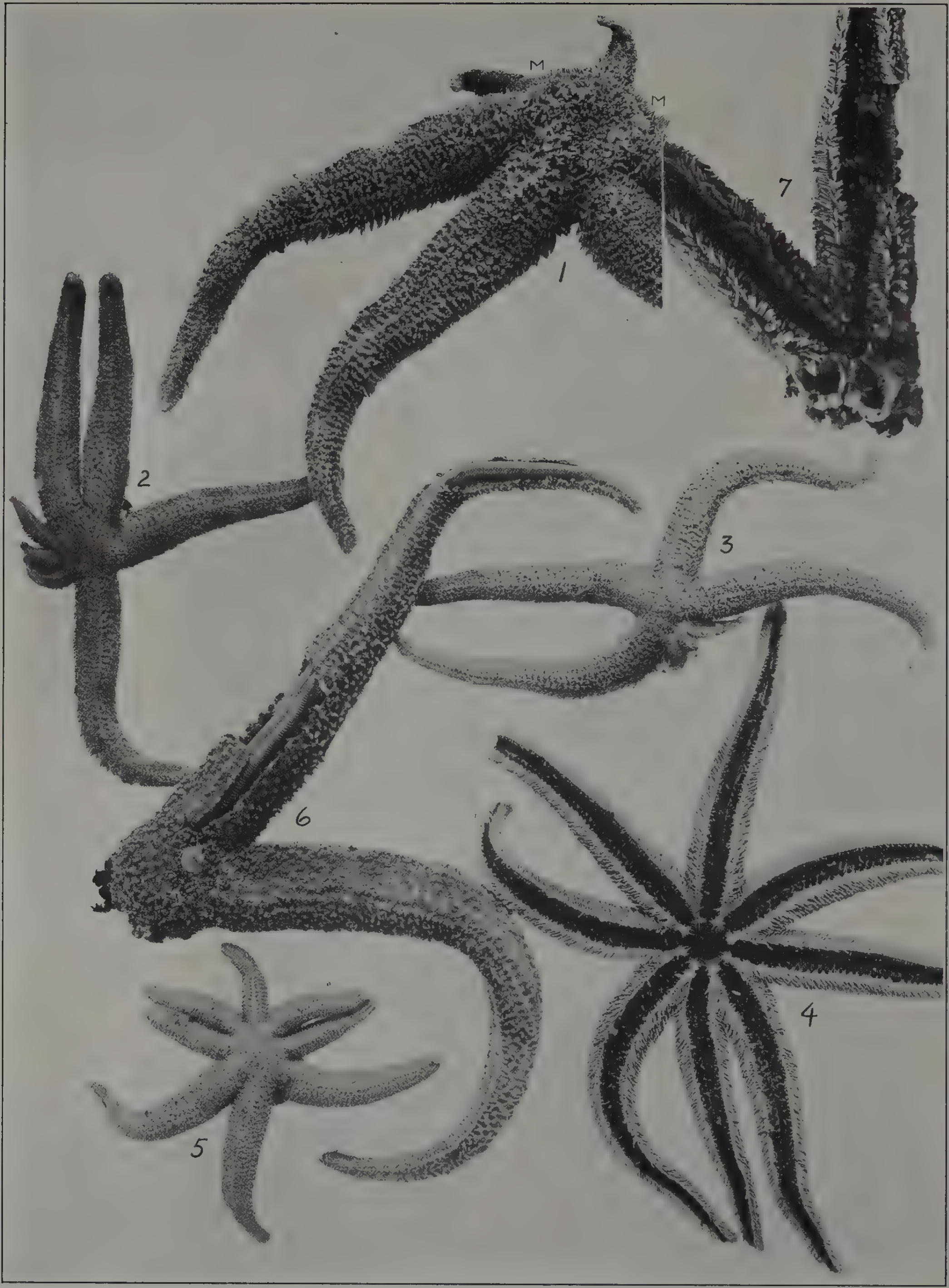


1–5. STEPHANASTERIAS ALBULA. 6, 7. APHANASTERIAS PYCNOPODIA

FOR EXPLANATION OF PLATE SEE PAGE FACING.

Plate 70

Enlarged × 1⅔

Figure 1. *Stephanasterias albula*, station 3548; large 7-rayed specimen, with large unguiculate straight pedicellariae; *M*, *M*, madreporic bodies.
2. Same, station 4792, seven rays.
3. Same, station 4777, eight rays.
4. Same, station 4792, eight rays.
5. Same, station 4792, eight rays.
6. *Aphanasterias pycnopodia*, type.
7. *Aphanasterias pycnopodia*, type.

Plate 71

Figure 1. *Stephanasterias albula*, station 4792; projection of skeleton from carinals, *C*, to inferomarginals, *I*, proximal third of ray; 1, 2, 3, 4, dorsolateral series of skeletal meshes; *AD*, direction of disk; *S*, superomarginals; ×12.

1*a*. Same, station 4792; mouth plates and first two pairs of adambulacrals; ×20.

1*b*. Same, abactinal pedicellaria, 0.25 mm., ×200.

1*c*. Same, station 3548; a straight pedicellaria from mouth plates, two views, 1.25 mm., ×25.

1*d*. Same, station 4792; abactinal straight pedicellaria, 0.54 mm., ×50.

1*e*. Same pedicellaria, ×25 for comparison with 1*c*.

1*f*. Same, station 3548; abactinal pedicellaria, ×50.

1*g*. Same, station 4792; two abactinal spinelets, 0.4 and 0.5 mm., ×100.

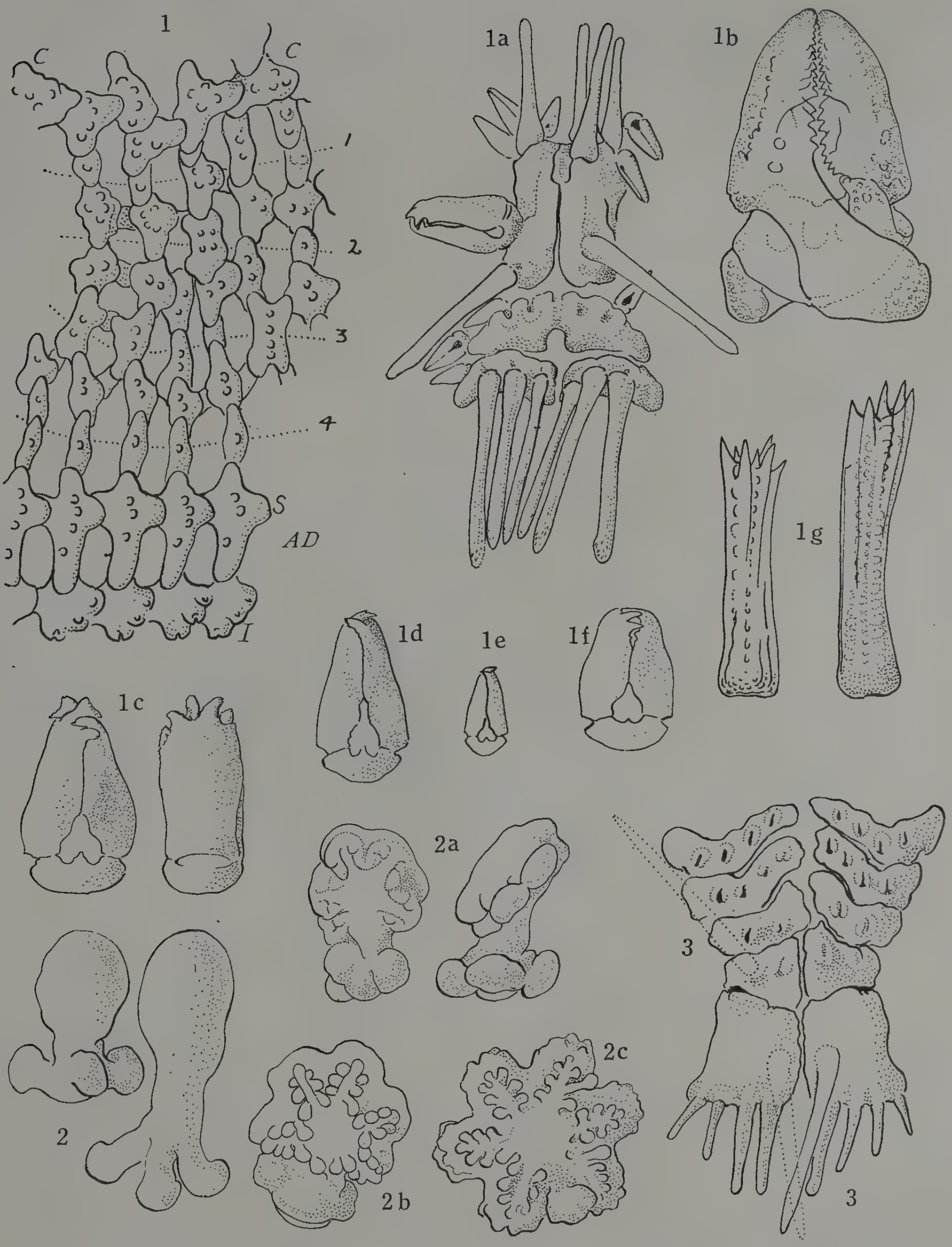
2. *Leptasterias aequalis*, embryos carried by female, drawn from living specimens, much enlarged.

2*a*. Two views of a later stage, rays beginning to appear; 3-lobed larval organ below; March 25, 1927; ×20.

2*b*. A still later stage (March 30, 1927), ×22.

2*c*. Stage in which the six rays are well defined and larval organ is disappearing (April 4, 1927).

3. *Perissasterias polyacantha*, 170 fathoms, northwest of Dassen Island, Cape Colony, No. 2875, Mus. Comp. Zoöl., oral angle, ×4.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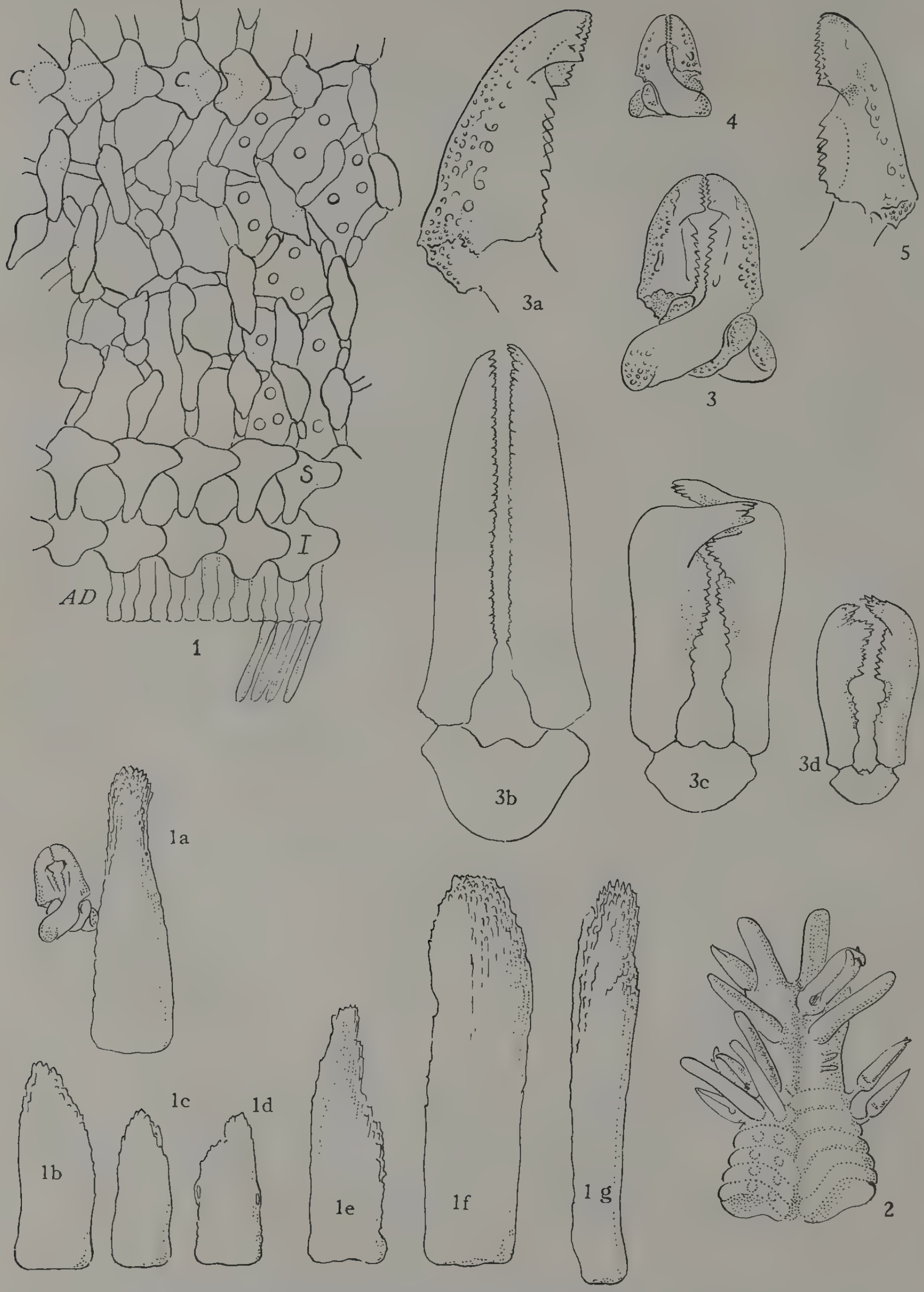
1. Stephanasterias albula. 2. Leptasterias aequalis. 3. Perissasterias polyacantha

For explanation of plate see page facing.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1–3. Aphanasterias pycnopodia. 4. Aphelasterias japonica. 5. Stephanasterias albula

For explanation of plate see page facing.

PLATE 72

FIGURE 1. *Aphanasterias pycnopodia.* Skeleton of ray; *C*, carinal, *S*, superomarginal, *I*, inferomarginal, *AD*, adambulacral plates; ×10, from about 14 mm. from oral angle; base of ray to right. The circles indicate position of the compound papulae.

1*a*–1*g*. Same, spines enlarged, ×50.

1*a*. A superomarginal, 0.9 mm., with a somewhat smaller than average crossed pedicellaria.

1*b*. A carinal, 0.67 mm.

1*c*, 1*d*, 1*e*. Dorsolateral spines (0.5, 0.49, 0.81 mm., respectively); 1*e* is from a plate just above the superomarginals.

1*f*. A rather heavy inferomarginal, 0.125 mm.

1*g*. An adambulacral, 0.13 mm.

2. Same, mouth plates and adoral carina, ×10. Two adambulacrals are shown with spines.

3, 3*a*. Same, crossed pedicellariae; 3, dorsolateral, 0.32 mm., ×100; 3*a*, a single jaw, ×200. Compare with 4 and 5.

3*b*, 3*c*, 3*d*. Same, straight pedicellariae; 3*b* is from furrow margin 0.8 mm. long, ×100; 3*c* (1 mm.) and 3*d* (0.63 mm.) unguiculate form from abactinal area, ×50.

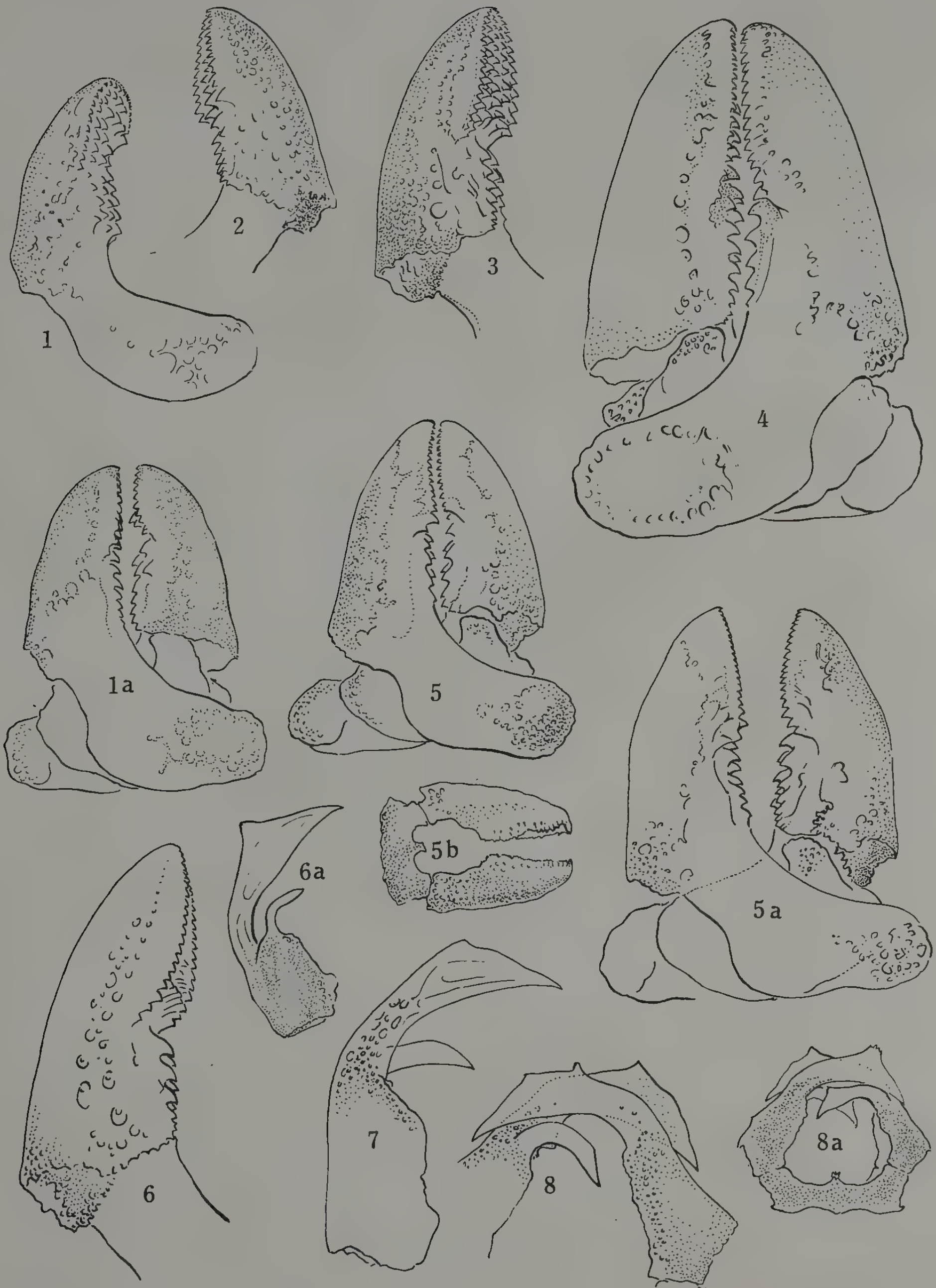
4. *Aphelasterias japonica*, abactinal pedicellaria, for comparison (0.17 mm.), ×100.

5. *Stephanasterias albula*, abactinal pedicellaria, ×200.

Plate 73

Crossed and furcate pedicellariae ×200 (except 8*a*)

Figure 1. *Pisaster ochraceus* forma *ochraceus*, Sitka, Alaska.
1*a*. Same, Monterey Bay, Calif., both 0.27 mm. long.
2. *Pisaster ochraceus* forma *confertus*, Departure Bay, British Columbia.
3. *Pisaster ochraceus* forma *nodiferus*, Tongass, Alaska, length 0.31 mm.
4. *Pisaster ochraceus segnis*, Laguna Beach, Orange County, Calif., length 0.4 mm.
5. *Pisaster giganteus*, small specimen, Monterey Bay, Calif.
5*a*. Same, from a giant specimen, length 0.30 mm.
5*b*. Same, type specimen; dermal straight pedicellaria 0.15 mm. long, ×200.
6. *Pisaster giganteus capitatus*, Laguna Beach, Calif.
6*a*. Same; jaw of a furcate pedicellaria; Venice, Calif.
7. *Pisaster ochraceus* forma *nodiferus*, Monterey Bay; jaw of a furcate pedicellaria.
8. *Pisaster ochraceus segnis*, type; jaws of a furcate pedicellaria.
8*a*. A whole pedicellaria, ×100.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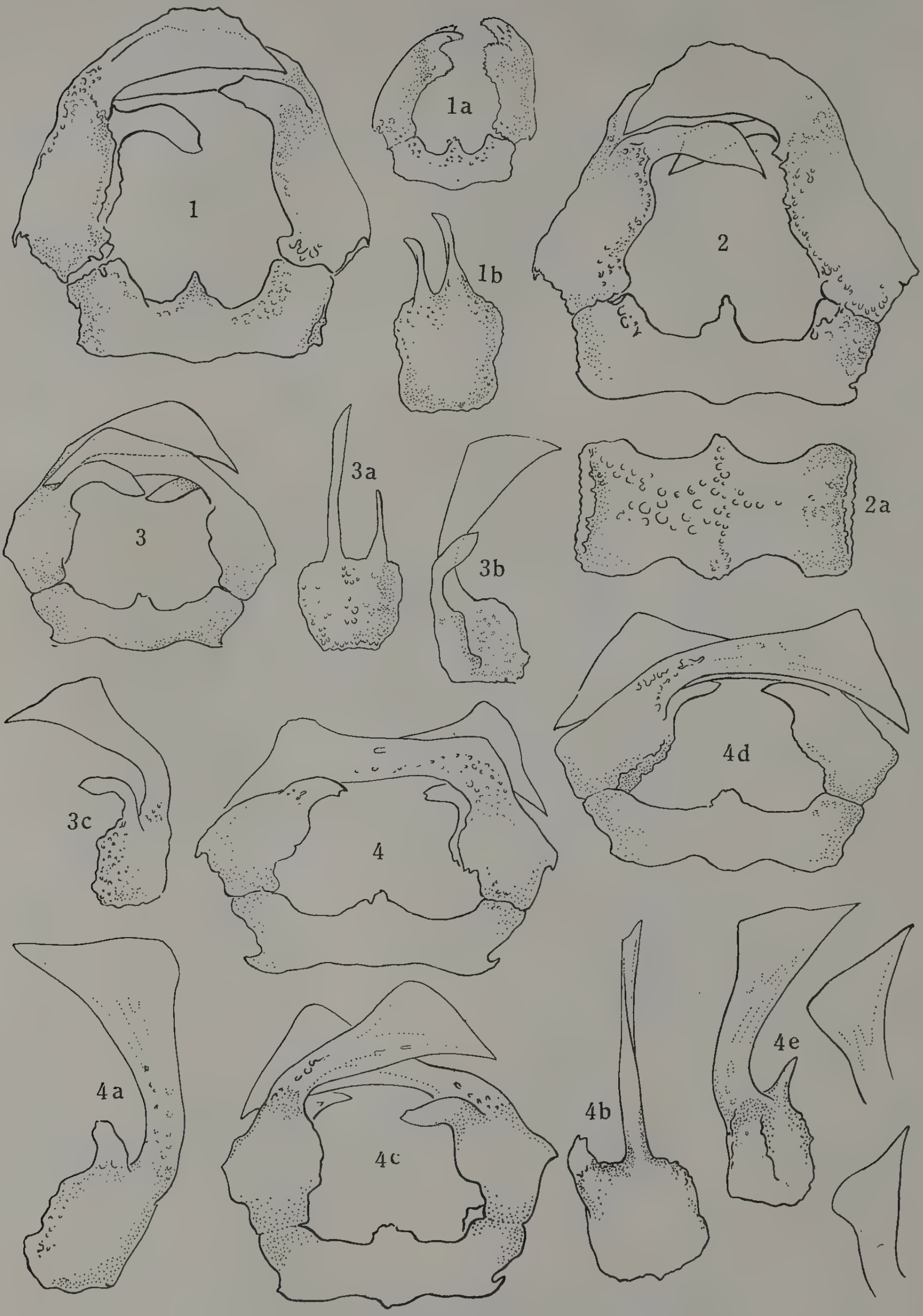
1–3, 7. Pisaster ochraceus. 4, 8. P. ochraceus segnis. 5. P. giganteus. 6. P. giganteus capitatus

For explanation of plate see page facing.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1, 2. Pisaster ochraceus. 3. P. giganteus. 4. P. brevispinus

For explanation of plate see page facing

PLATE 74

Furcate straight pedicellariae ×200 unless otherwise specified

FIGURE 1. *Pisaster ochraceus* forma *confertus*, Departure Bay, British Columbia, from abactinal surface.

1*a*. Same specimen, an intermediate form, ×100.

1*b*. Same specimen, back of jaw, ×100. Note the height of base in proportion to blade compared with *giganteus* (3*a*) and *brevispinus* (4*b*).

2. *Pisaster ochraceus* forma *ochraceus*, Monterey Bay, Calif., abactinal, 0.29×0.31 mm.

2*a*. Basal piece of above seen from below.

3. *Pisaster giganteus*, large specimen, Monterey Bay; an abactinal pedicellaria, 0.2×0.215 mm.

3*a*, 3*b*. Two jaws, same specimen. Note height of base in proportion to blade.

3*c*. From a small Monterey specimen.

4. *Pisaster brevispinus* forma *paucispinus*, Barclay Sound, British Columbia, 0.32 mm. diameter.

4*a*, 4*b*. Same, station 4219; giant specimen.

4*c*. Forma *brevispinus*, San Juan Islands, Wash., giant specimen, diameter 0.27 mm.

4*d*. Forma *brevispinus*, Monterey Bay (station 4501).

4*e*. Forma *paucispinus*, Monterey Bay (three jaws).

PLATE 75

Pisaster ochraceus

FIGURE 1. Portion of actinal and lateral skeleton from near base of ray of a medium-sized specimen from Monterey Bay; *S*, superomarginals; *I*, inferomarginals; *a*1–*a*5, actinal plates, of which three transseries are shown. The secondary plates are shaded darker than the primaries. The adambulacrals are adjacent to the three lowermost, or innermost, actinals, ×8.

2. Mouth plates and adoral carina of a medium-sized specimen from Monterey Bay, ×8.

3. Actinal skeleton of a small specimen (R 80 mm.) showing three longiseries of actinal plates and the lower-lying plates of the interbrachial septum. The adambulacral plates are shown as a dark band, without detail. *I*, inferomarginals; a^1–a^3, actinal plates; *int.*, interradial line; Monterey Bay; ×8.

4. Abactinal skeleton of a young specimen (R 20 mm.) from Departure Bay, British Columbia, ×10. On the left is the central portion of the disk, with the dorsal and lateral skeleton of the proximal part of right half of ray, on right. (In this specimen there is one series of well-developed actinal plates, with the second just appearing adjacent to adambulacrals; actinal skeleton not shown.) The upper dotted line marks the carinal series (*R–R'*) while the lower indicates the interradial line. *B*, primary interradial plates, one carrying the madreporite; *C*, primary central plate; *DL*, dorsolaterals; *I*, inferomarginals; *S*, superomarginals; *R*, primary radial plates.

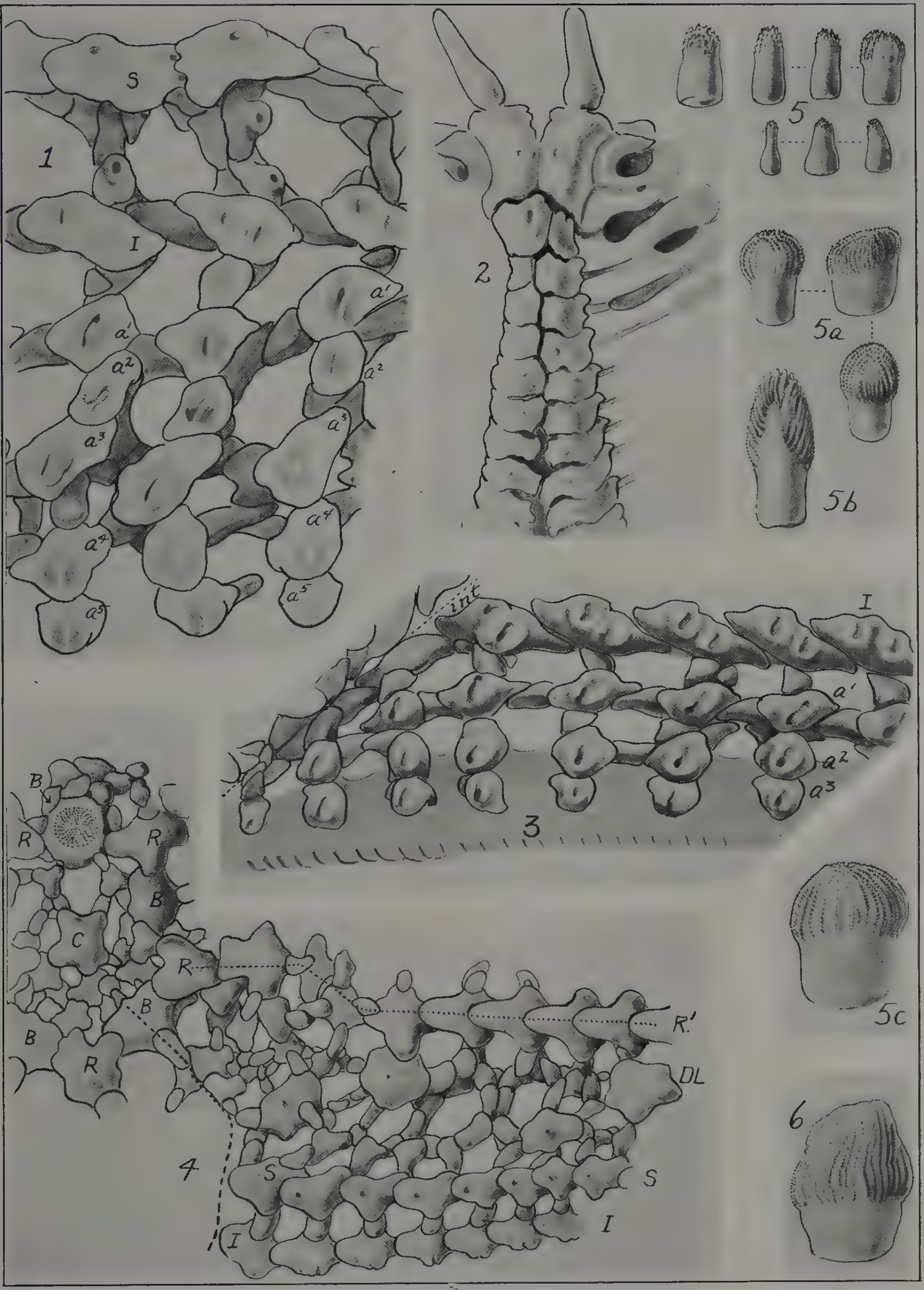
5. Forma *confertus*, Departure Bay, British Columbia; seven abactinal spinelets, 0.85 to 1.2 mm. in length for comparison with 5*a* and 5*c*.

5*a*. Forma *ochraceus;* three abactinal spines from a Monterey specimen, ×10.

5*b*. An inferomarginal spine from same specimen.

5*c*. Forma *nodiferus*, Tongass, Alaska; an abactinal spine, ×10.

6. *Pisaster ochraceus segnis* forma *nodiferus*, Laguna Beach, Orange County, Calif.; an abactinal spine, ×10.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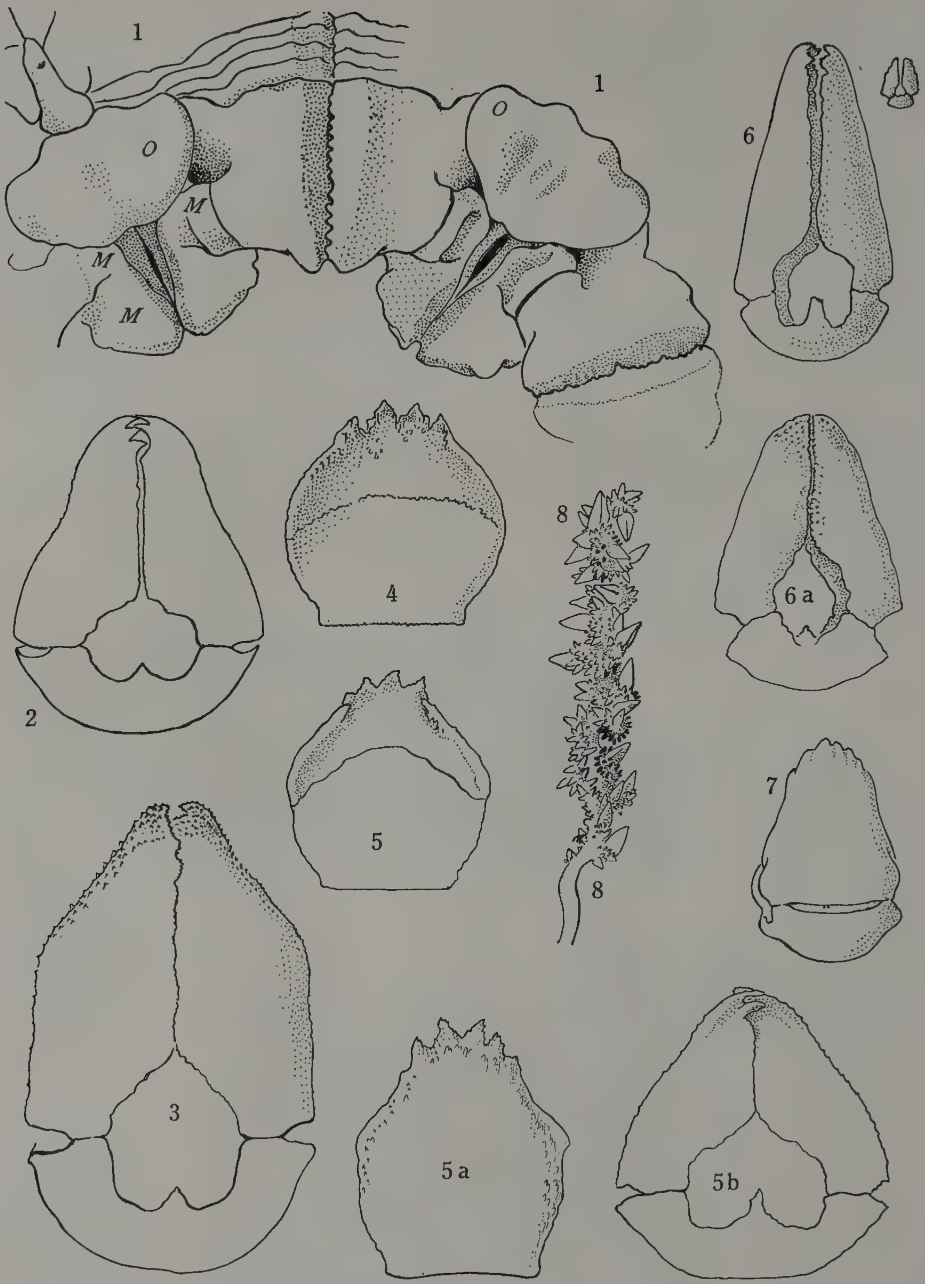
Pisaster ochraceus

For explanation of plate see page facing.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5 a
5 b

1–7. PISASTER OCHRACEUS. 8. P. BREVISPINUS

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 76

Pisaster ochraceus

FIGURE 1. Portion of actinostomial ring showing two odontophores (O) with proximal end of ambulacral system between, mouth plates (*M*) below odontophores, ×10.

2. Forma *confertus*, Puget Sound; an unguiculate straight pedicellaria from among actinal spines, 1 mm. long, ×50.

3. Forma *confertus*, Departure Bay, British Columbia; a large unguiculate pedicellaria from the actinal interradial area, 1.5 mm., ×50.

4. Forma *ochraceus*, Sitka, Alaska; inside of a valve of a dorsolateral unguiculate pedicellaria, ×50.

5, 5*a*. Forma *ochraceus*, Monterey Bay, Calif.; two valves of characteristic unguiculate pedicellariae, 5 being the inside, 5*a* the outside.

5*b*. Same specimen, side view, ×50.

6. Forma *ochraceus*, Monterey Bay; the central large pedicellaria from an adambulacral cluster (1 mm., ×50) with one of the small pedicellariae drawn to scale (0.15 mm.).

6*a*. One of the small pedicellariae (0.22 mm.) of an adambulacral cluster, ×200.

7. Actinal pedicellaria from a variation of forma *confertus*, Puget Sound (Tacoma), 1.3 mm., ×25.

8. *Pisaster brevispinus*, station 4219; a festoon of straight pedicellariae from the adoral carina, ×3. These festoons are very numerous and long in this large specimen.

PLATE 77

FIGURE 1. *Pisaster giganteus;* section out of actinal area, viewed from aboral end to show actinal and inferomarginal spines; medium-sized specimen from Monterey, ×10. *a, a, a,* actinal plates; *ad,* adambulacral; *am,* lower end of ambulacral ossicle; *x,* superactinal buttress mentioned in text, and side of one of the superactinal fenestrated pits.

2, 2*a*, 2*b*. *Pisaster giganteus*, type; three abactinal spines 2.7–3 mm. long, ×10.

3. *Pisaster giganteus*, Monterey Bay; three abactinal spines, 1.6 mm. long, ×10.

3*a*. Same; an abactinal spine from a medium-sized specimen, ×25.

3*b*, 3*c*. Same; actinal and inferomarginal spines, same specimen as 3 and 3*a*, ×10.

4. *Pisaster giganteus capitatus*, Laguna Beach, Calif.; two abactinal spines, 2.8 mm., ×10.

4*a*. Same specimen; an inferomarginal spine, ×10.

5. *Pisaster giganteus*, Monterey Bay; three clusters of abactinal papulae drawn from a rather smaller than medium-sized live specimen, ×6.

6. *Pisaster giganteus;* pedicellaria from actinal interradial channel, same specimen as 3 and 5, ×25.

6*a*. Same specimen, from intermarginal channel, 1.2 mm., ×25.

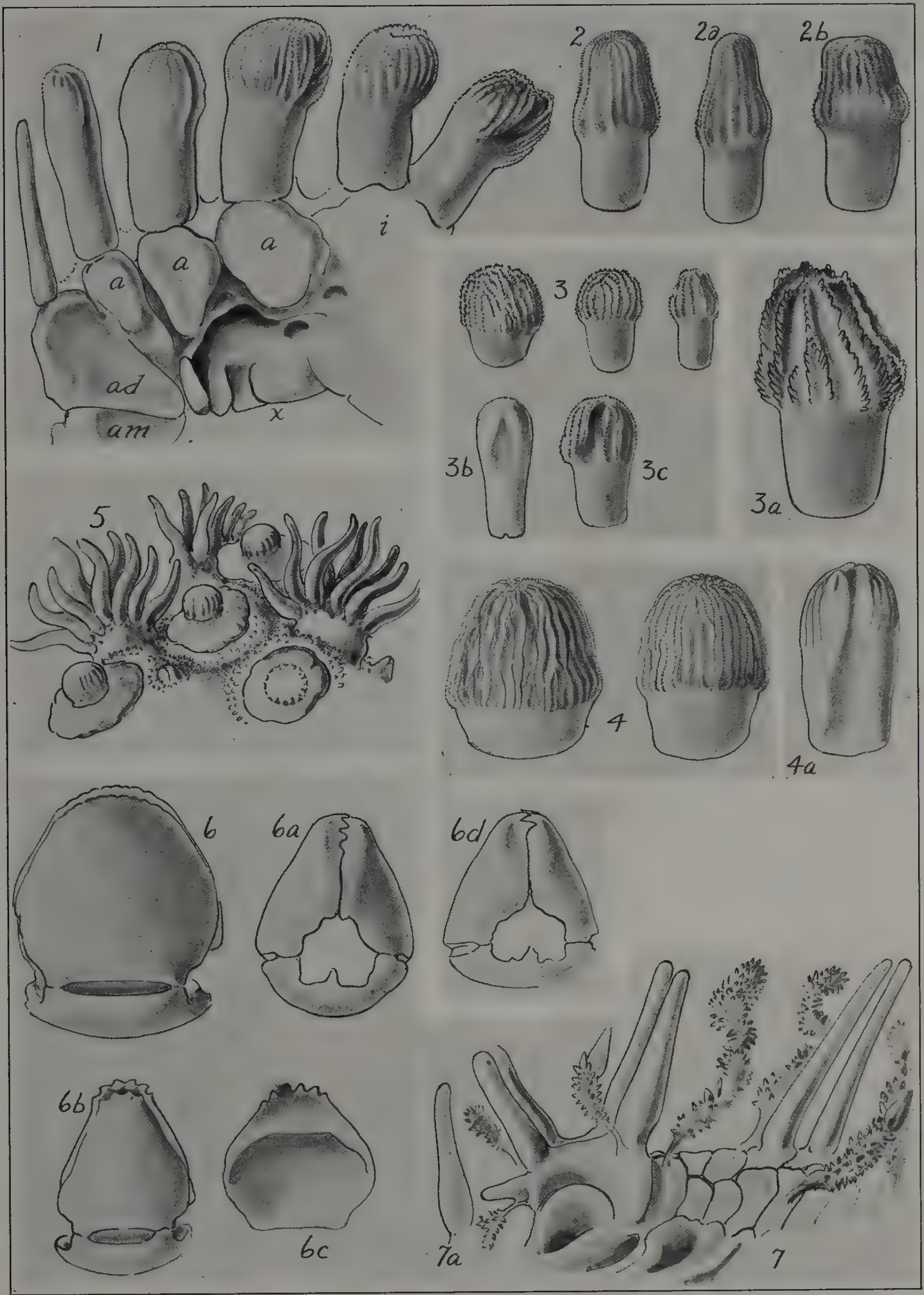
6*b*. Large specimen from Monterey; an intermarginal stone-hammer pedicellaria, 1.2 mm., ×25.

6*c*. Same specimen as 6*a*; inside of a valve or jaw.

6*d*. Type of *P. giganteus;* an abactinal pedicellaria, 1.12 mm., ×10.

7. *Pisaster giganteus;* mouth plates and inner part of adoral carina of a medium-sized Monterey example, showing distorted development of first few adambulacral plates, ×8. This is from a dry specimen and the prominent festoons of straight pedicellariae are indicated without detail.

7*a*. Actinostomial spine of another specimen.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6a
6d
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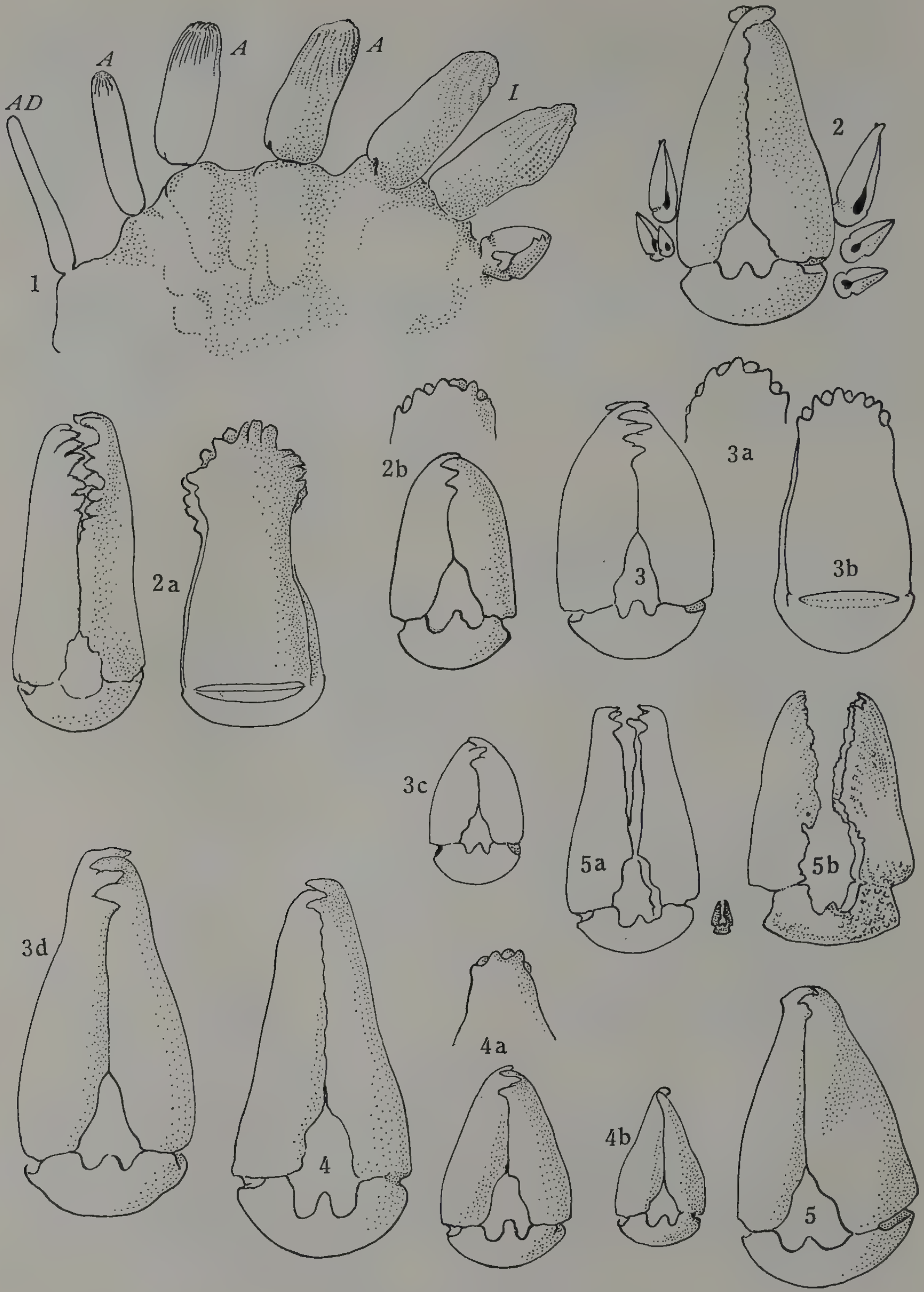
1–3, 5–7. PISASTER GIGANTEUS. 4. P. GIGANTEUS CAPITATUS

FOR EXPLANATION OF PLATE SEE PAGE FACING.


AD
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5a
5b

1–4. Pisaster brevispinus. 5. P. giganteus

For explanation of plate see page facing.

Plate 78

Figure 1. *Pisaster brevispinus;* adambulacral, actinal, and infermomarginal plates and spines of forma *brevispinus*, viewed from a cut end of ray, Monterey Bay specimen, ×10. *AD*, adambulacral spine; *A*, actinals; *I*, inferomarginals.

2. Same; large specimen of forma *brevispinus* from Lopez Island, San Juan Islands, Wash. An adambulacral pedunculate pedicellaria, with a few accessories, ×25.

2*a*. Same specimen, two views of a large actinal axillary pedicellaria, 4 mm. long, ×12.5.

2*b*. Same specimen, abactinal pedicellariae, ×25.

3. Same; forma *paucispinus*, from Nanaimo, British Columbia, having very numerous "major" pedicellariae; side view of an intermarginal, 1.6 mm. long, ×25.

3*a*, 3*b*. Others from intermarginal groove.

3*c*. One of the smaller abactinal ones, 0.96 mm. long, ×25.

3*d*. One of the larger actinal pedicellariae, same specimen, base of ray 2.4 mm., ×25.

4. Forma *brevispinus*, Monterey Bay; an adambulacral pedunculate pedicellaria, 2.4 mm., ×25.

4*a*. Same, Monterey, intermarginal, two views, 1.28 mm. long, ×25.

4*b*. Same specimen, actinal, ×25.

5. *Pisaster giganteus*, type; a slightly twisted adambulacral pedicellaria, ×25.

5*a*. Same, Monterey specimen; adambulacral pedicellaria with one of the smaller of the cluster drawn to scale, ×25.

5*b*. The small pedicellaria of 5*a* (from an adambulacral bouquet), ×200.

PLATE 79

FIGURE 1. *Pisaster ochraceus* forma *ochraceus*, Puget Sound; mouth plates and proximal adambulacrals from side, ×10.

2. *Pisaster brevispinus* forma *brevispinus*, San Juan Islands, Wash.; cluster of spines on an abactinal prominence, ×10.

2*a*. Same specimen; mouth plates and adoral carina; eight pairs of proximal adambulacral plates lack spines.

2*b*. Same specimen, an abactinal crossed pedicellariae (0.24 to 0.27 mm.), ×200.

3, 3*a*. *Pisaster brevispinus* forma *paucispinus*, Monterey Bay, abactinal spines, ×10.

3*b*. Same, Barclay Sound, British Columbia, ×10.

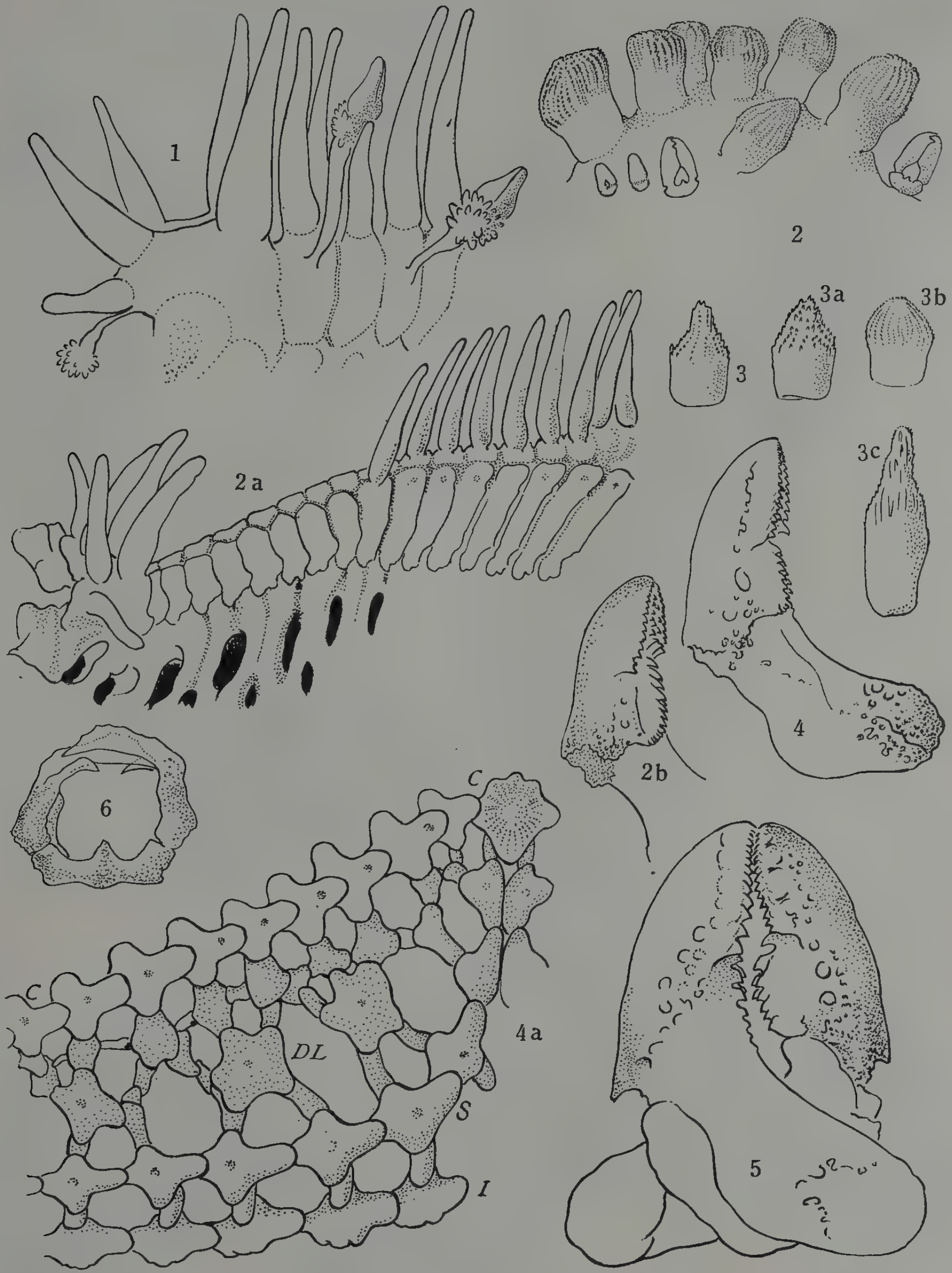
3*c*. Forma *brevispinus*; abactinal spine, ×10, from large specimen, somewhat intermediate, San Juan Islands, Wash.

4. *Pisaster brevispinus* forma *brevispinus*, Monterey Bay; crossed pedicellaria, abactinal surface, ×200.

4*a*. Forma *paucispinus*, Monterey Bay; skeleton of young specimen, base of ray, ×10 *C*, carinal plates; *DL*, dorsolaterals; *I*, inferomarginals; *S*, superomarginals. The madreporite is shown on right, at top of an interradial line.

5. *Pisaster brevispinus* forma *paucispinus*, station 4219; a large crossed pedicellaria from inferomarginal spines, ×200; abactinal pedicellariae similar to 4.

6. *Pisaster ochraceus*, Monterey Bay; a furcate pedicellaria 0.25 by 0.25 mm., ×100.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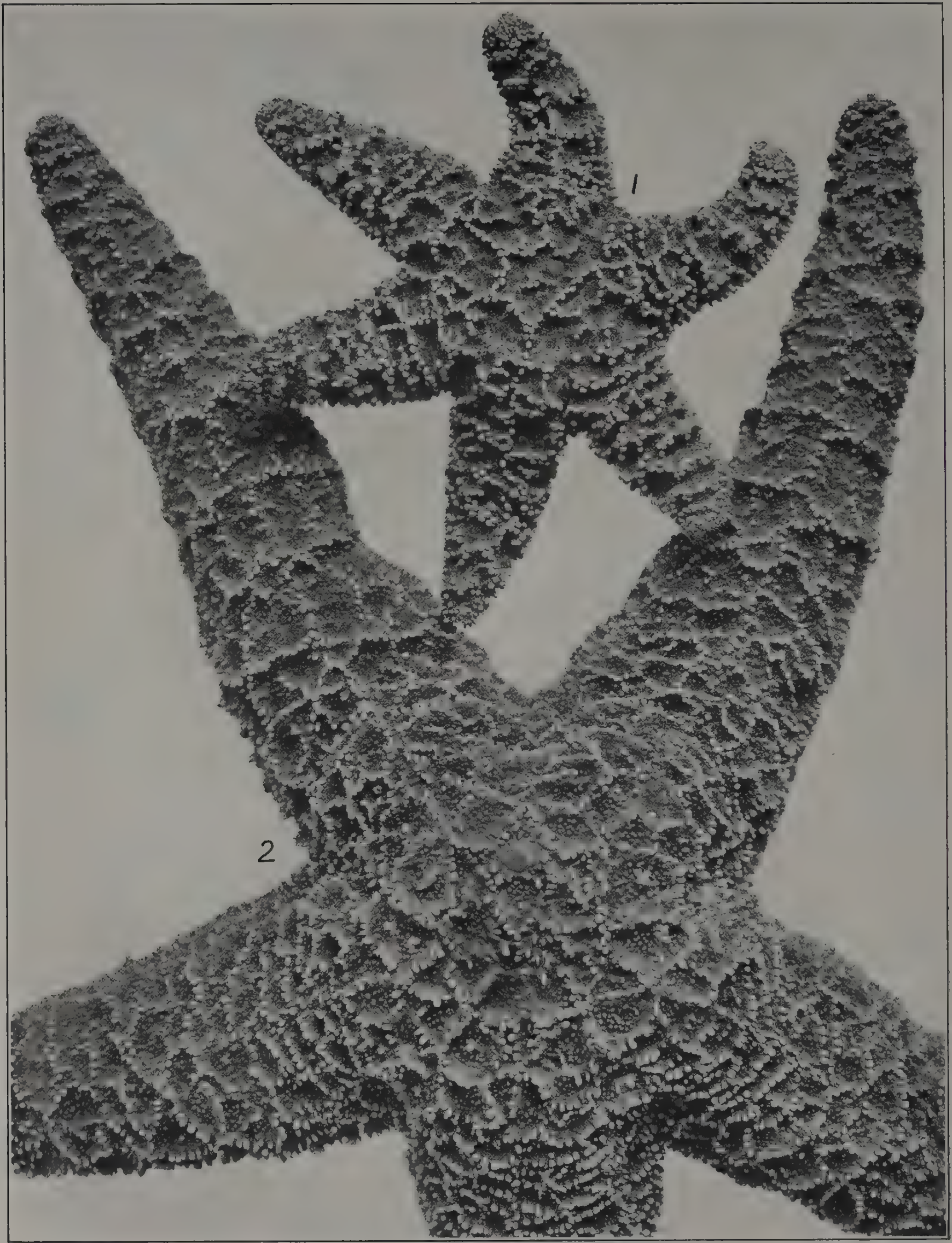
1, 6. Pisaster ochraceus. 2–5. P. brevispinus

For explanation of plate see page facing.



Pisaster ochraceus

For explanation of plate see page facing

PLATE 80

Pisaster ochraceus forma *ochraceus*, slightly reduced

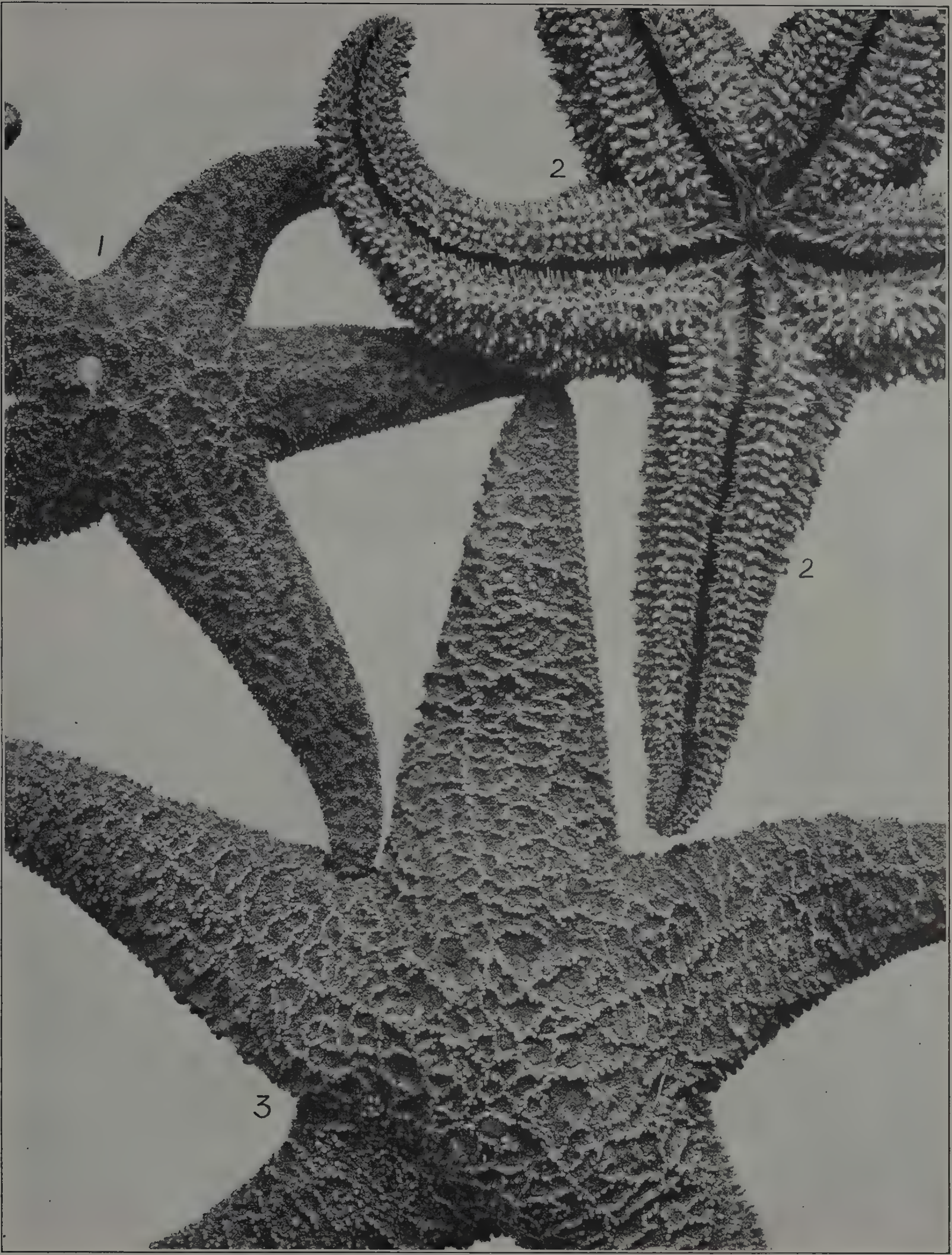
FIGURE 1. Trinidad Head, Calif.
2. Monterey Bay, Calif. These are characteristic of the open, exposed, rocky coast.

PLATE 81

FIGURE 1. *Pisaster ochraceus* forma *confertus*, Boundary Bay, British Columbia, an extreme example, ×1.

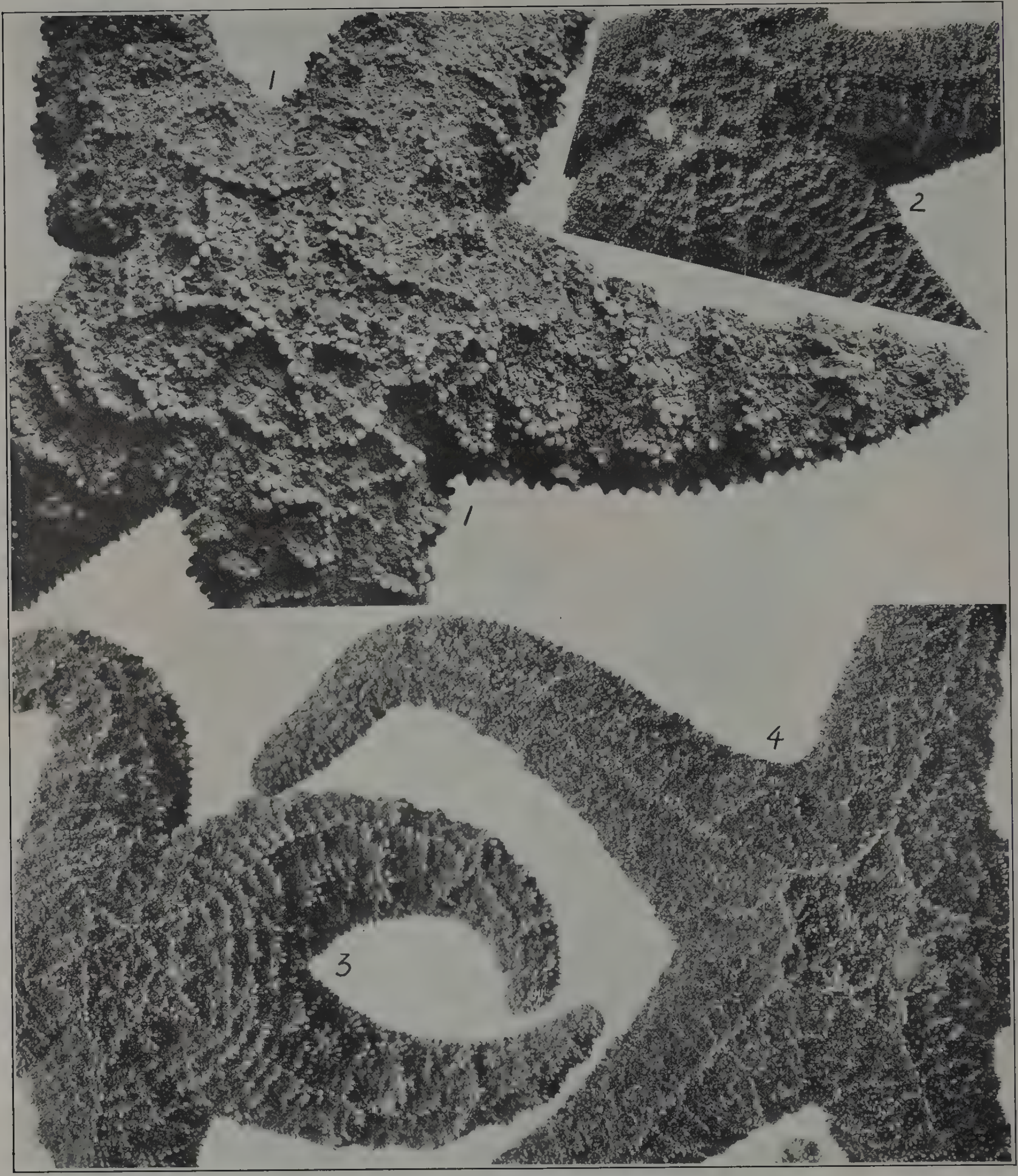
2. *Pisaster ochraceus* forma *confertus-nodiferus*, Departure Bay, British Columbia, ×1.

3. *Pisaster ochraceus* forma *ochraceus*, Sitka, Alaska, No. 5984, ×1. This is regarded as typical of forma *ochraceus*.



PISASTER OCHRACEUS

FOR EXPLANATION OF PLATE SEE PAGE FACING.



PISASTER OCHRACEUS

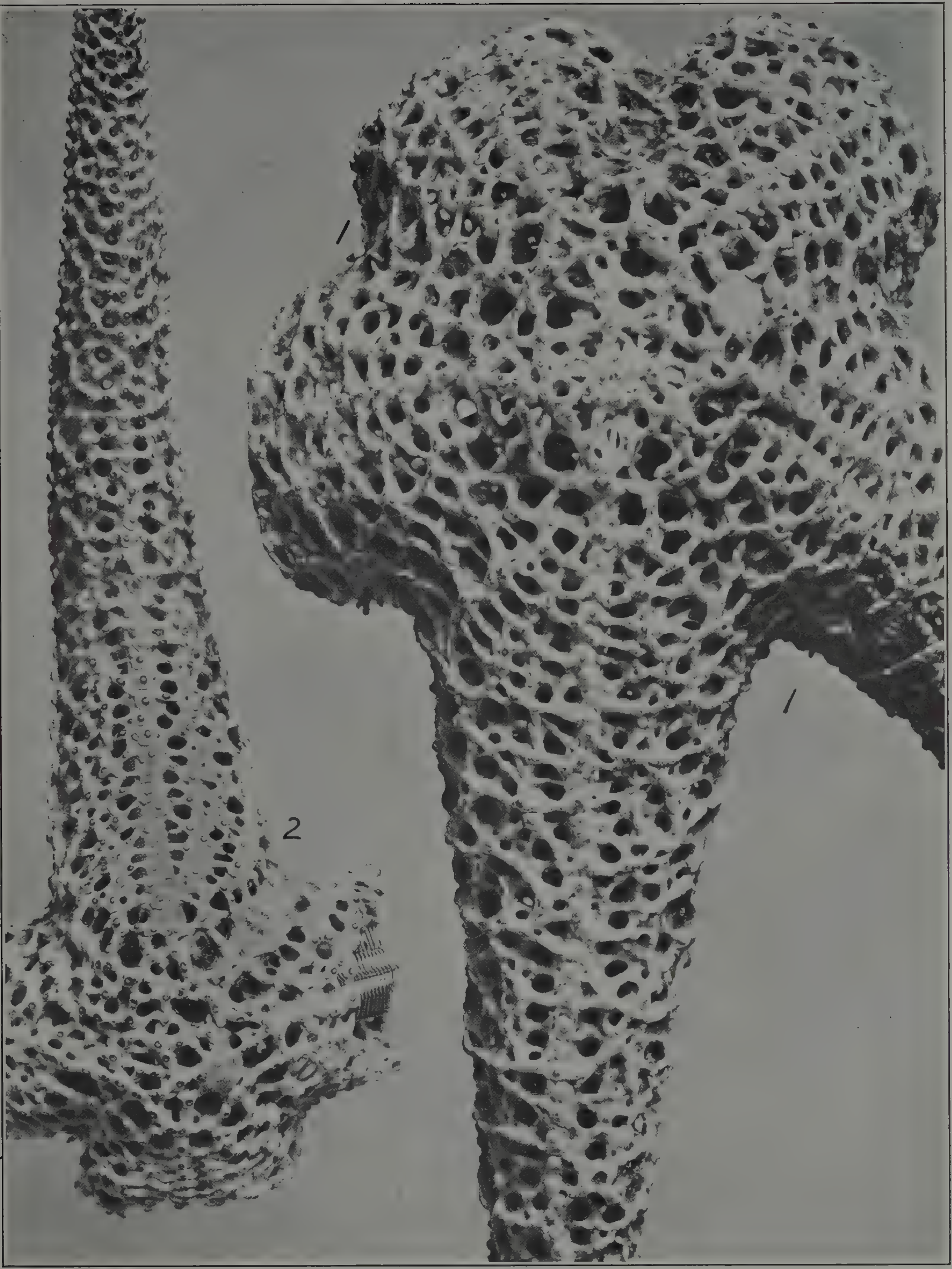
FOR EXPLANATION OF PLATE SEE PAGE FACING

PLATE 82

FIGURE 1. *Pisaster ochraceus* forma *nodiferus*, Tongass, Alaska, ×1.
2. *Pisaster ochraceus* forma *confertus*, Departure Bay, British Columbia, ×1.
3. *Pisaster ochraceus* forma *confertus-nodiferus*, Departure Bay, British Columbia, ×1.
4. *Pisaster ochraceus* forma *confertus*, Departure Bay, British Columbia, ×1.

PLATE 83

FIGURE 1. *Pisaster ochraceus*, Monterey Bay, Calif.; cleaned to show abactinal skeleton.
2. *Pisaster giganteus*, Monterey Bay, Calif.; abactinal skeleton.



1. PISASTER OCHRACEUS. 2. P. GIGANTEUS

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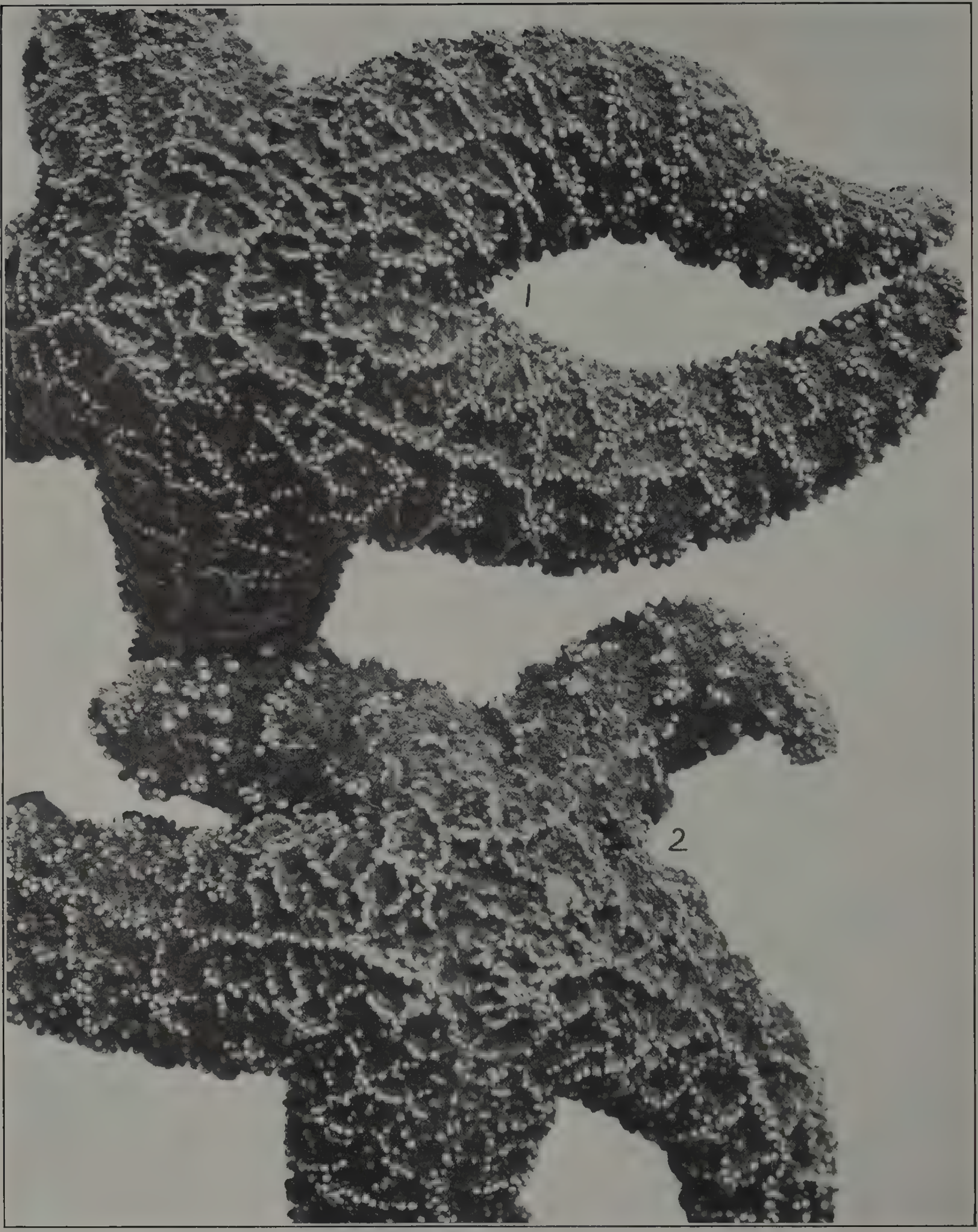


Pisaster ochraceus segnis

For explanation of plate see page facing

PLATE 84

FIGURE 1. *Pisaster ochraceus segnis*, type, Lower California, 16 miles south of international boundary, ×1.

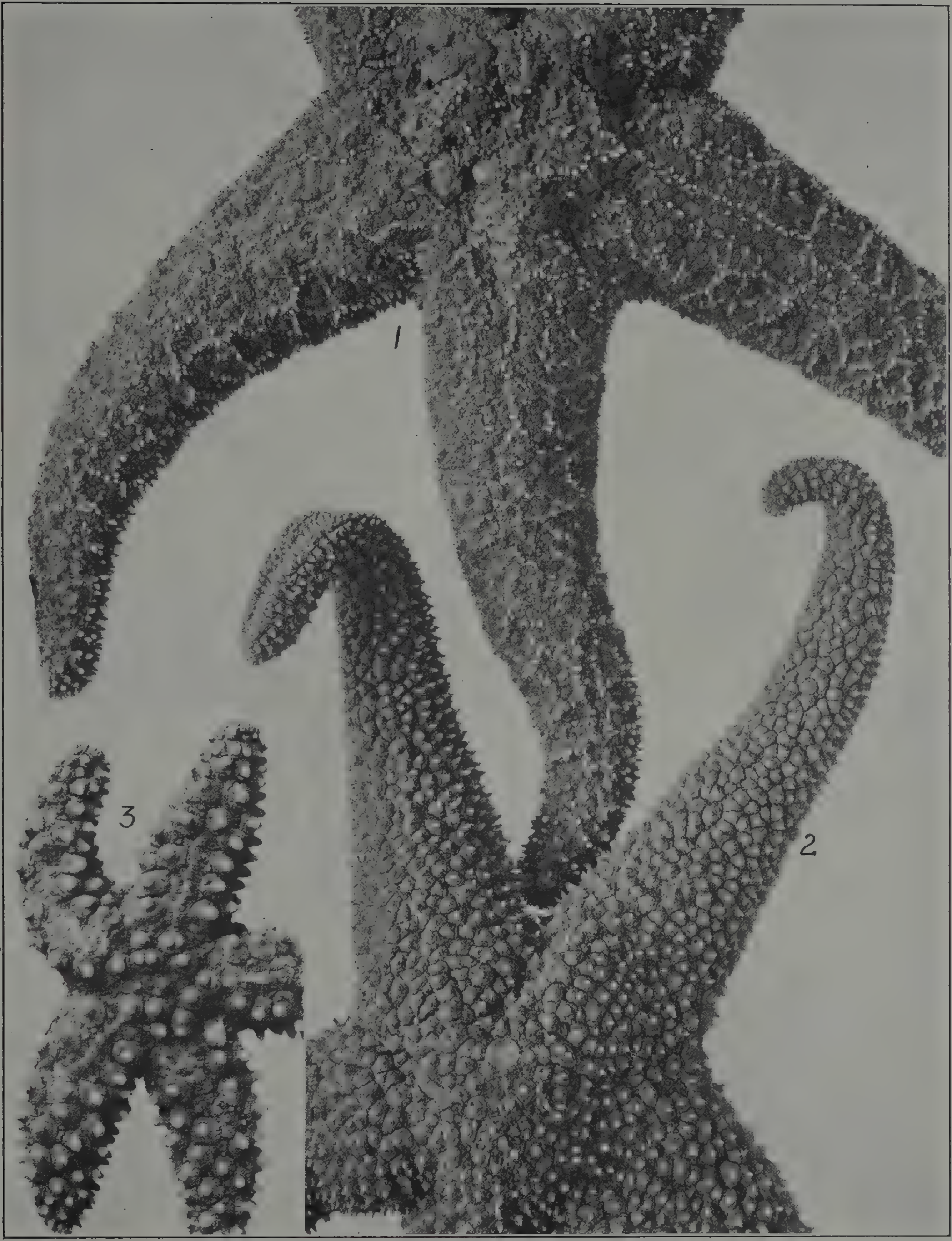
2. Same, specimen with two regenerating rays showing structure of forma *nodiferus*, ×1.

PLATE 85

FIGURE 1. *Pisaster ochraceus* forma *ochraceus*, Monterey Bay, alcoholic specimen, ×1.

2. *Pisaster giganteus*, Monterey Bay, ×1. Specimens from rock pools of the intertidal zone are generally of this size to 50 per cent larger.

3. *Pisaster giganteus capitatus*, San Diego, Calif., young specimen, ×1¼.



1. PISASTER OCHRACEUS. 2. P. GIGANTEUS. 3. P. GIGANTEUS CAPITATUS

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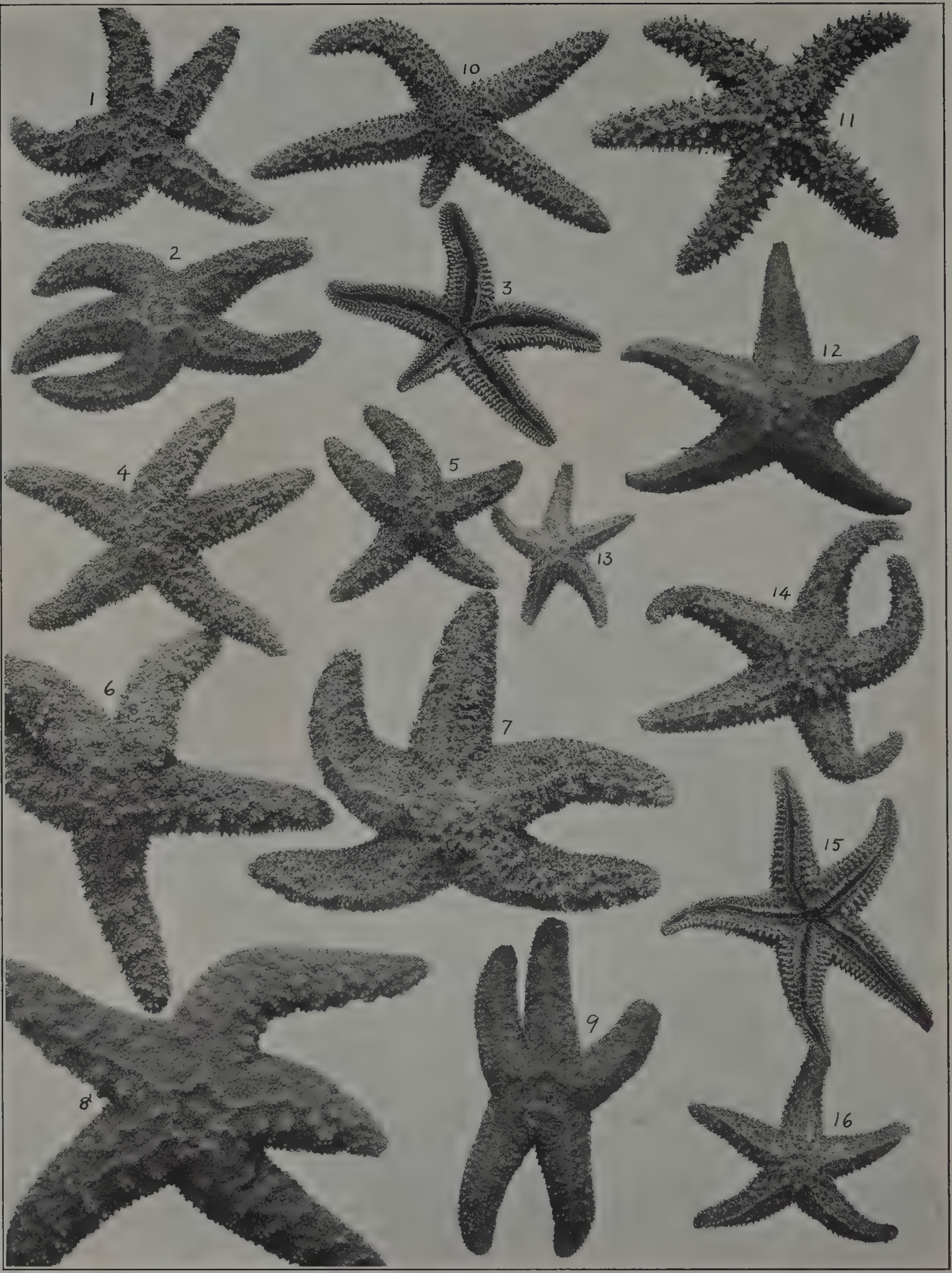
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1–9. Pisaster ochraceus. 10. Evasterias troschelii. 11. Pisaster giganteus. 12–16. Pisaster brevispinus

For explanation of plate see page facing.

PLATE 86

Young stages of *Pisaster* and *Evasterias*, ×1

FIGURES 1–9. *Pisaster ochraceus*, Departure Bay, British Columbia. Forma *nodiferus*, Figures 1, 3, 5, 6, 8 (alcoholic). Forma *confertus*, Figure 2. Forma *confertus-nodiferus*, Figures 4, 7. Forma *ochraceus-nodiferus*, Figure 9 (alcoholic).

10. *Evasterias troschelii*, Departure Bay, British Columbia.

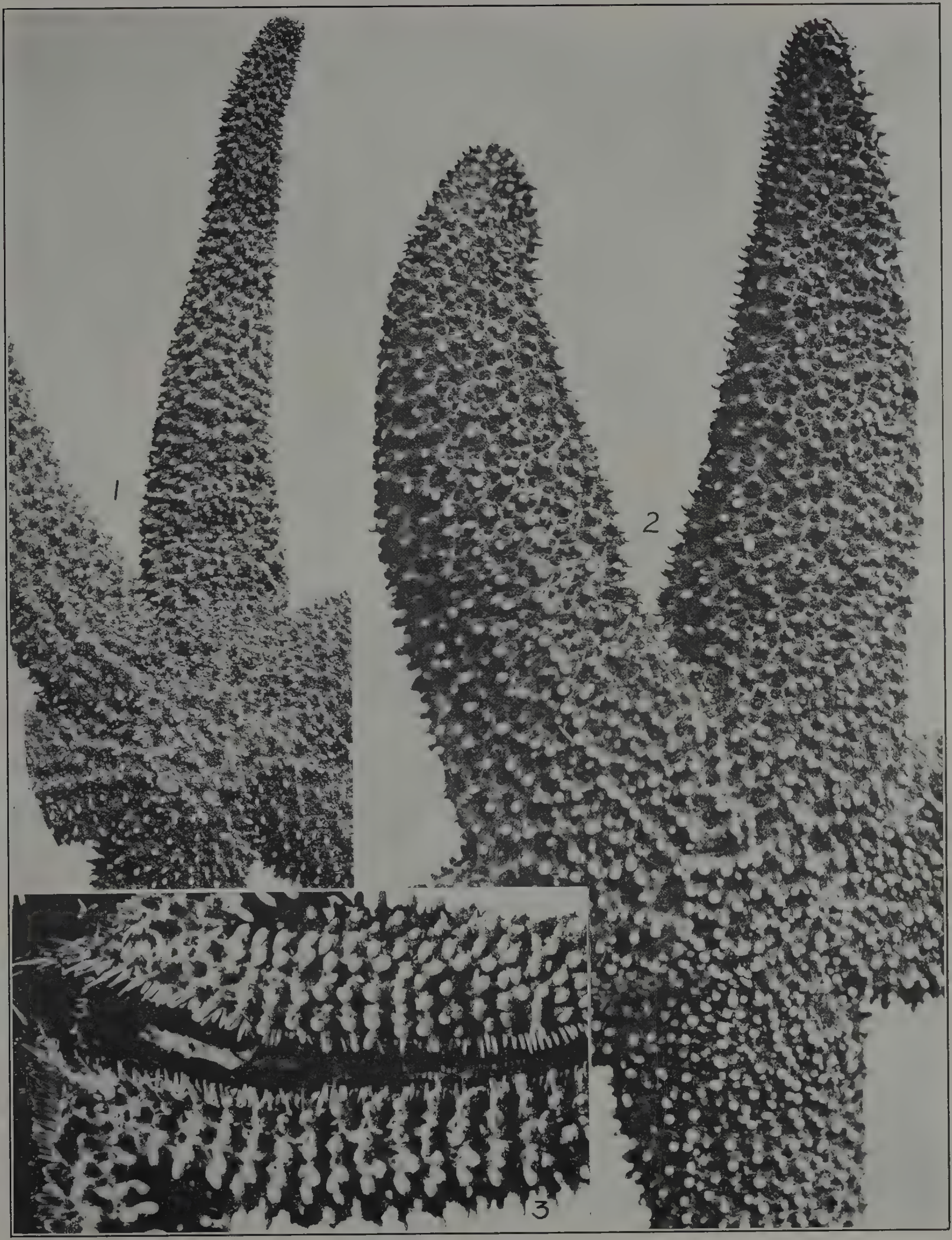
11. *Pisaster giganteus*, Monterey Bay, Calif.

12–16. *Pisaster brevispinus*, Monterey Bay. All young *P. brevispinus* are forma *paucispinus*. Figure 12 is an alcoholic specimen.

PLATE 87

Pisaster giganteus, Monterey Bay, Calif.

FIGURE 1. Six-rayed example of the slender-spined forma from shallow water offshore, ×¾.
2. Forma with heavier spines, although not an extreme example, ×⅘. This is a well-fed specimen from the piles of a wharf whence it had crawled from shallow water.
3. Actinal surface, base of ray, ×1.



PISASTER GIGANTEUS

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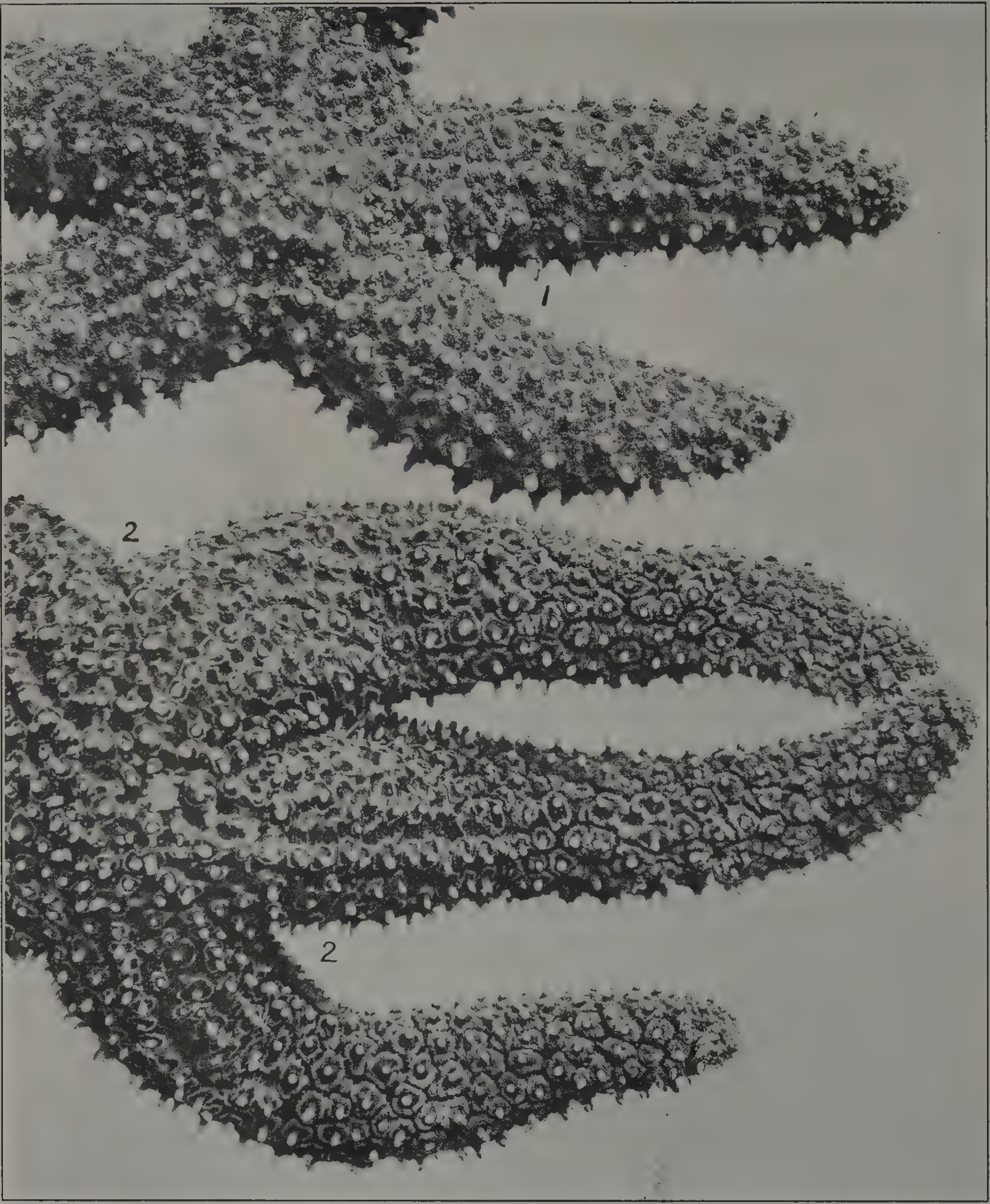


Pisaster giganteus capitatus

For explanation of plate see page facing

PLATE 88

Pisaster giganteus capitatus, ×$^{15}/_{16}$

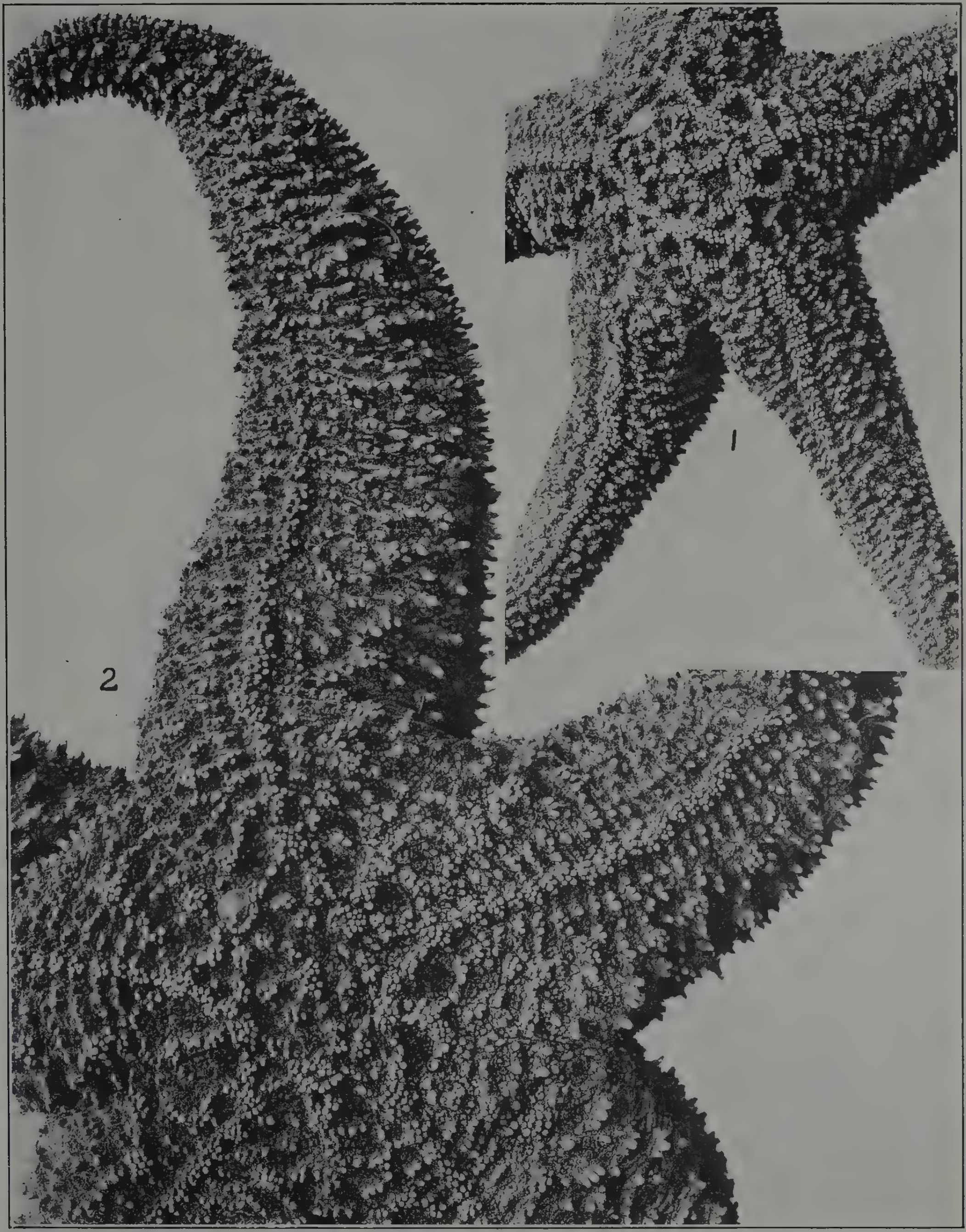
FIGURE 1. Forma with more widely spaced and heavier spines, Lower California, 16 miles south of international boundary.

2. Forma with slenderer, more numerous spines, Venice, Los Angeles County, Calif.

PLATE 89

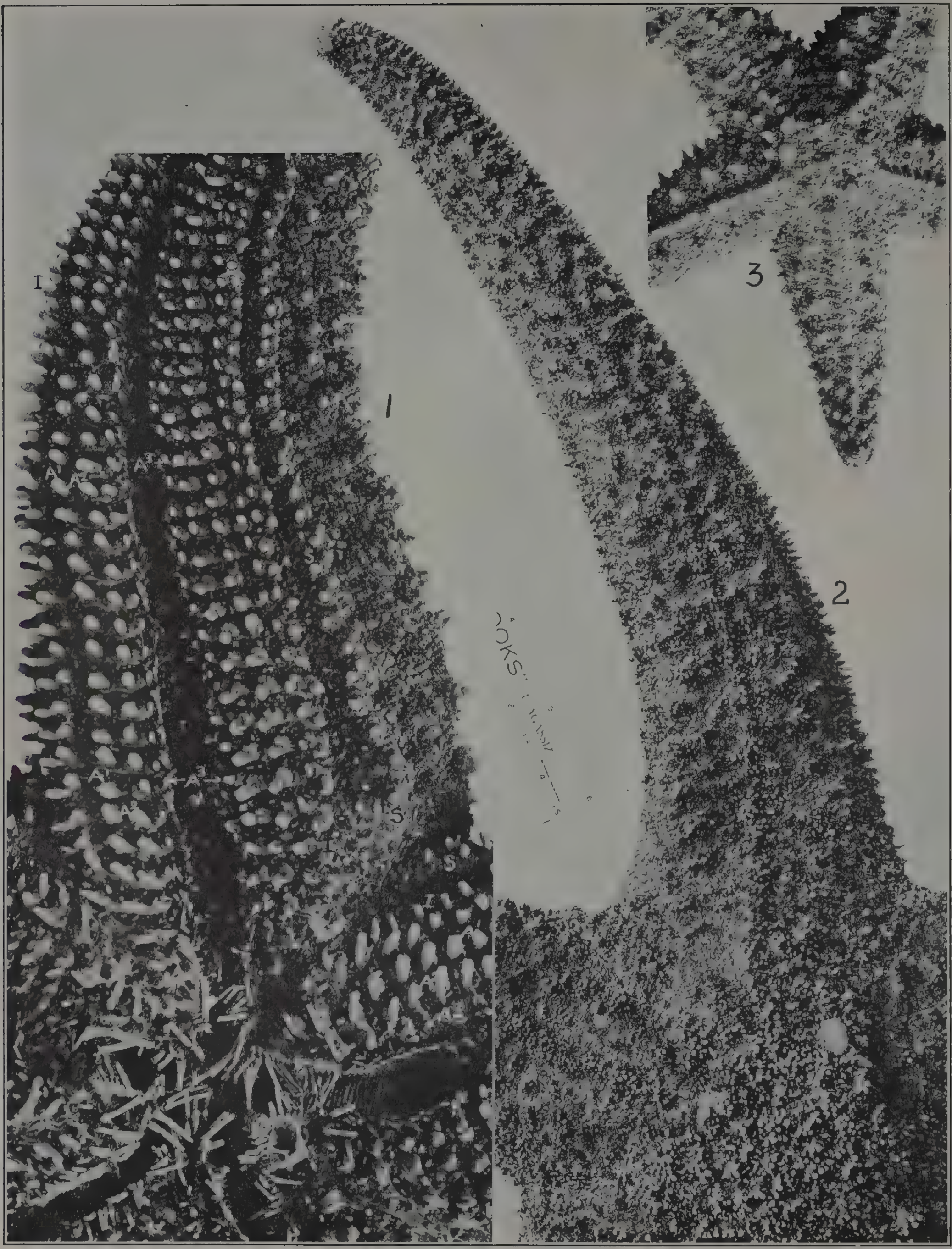
Pisaster brevispinus forma *brevispinus*, natural size

FIGURE 1. An extreme of the multispinous variety from Bolinas, Marin County, Calif.
2. A large specimen from Monterey Bay, Calif.



Pisaster brevispinus

For explanation of plate see page facing.



PISASTER BREVISPINUS

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 90

Pisaster brevispinus

FIGURE 1. Forma *brevispinus*, actinal view of Plate 89, Figure 2, Monterey Bay, ×1⅓. A^1–A^3, three series of actinal plates (spines); *I*, inferomarginals; *S*, superomarginals.

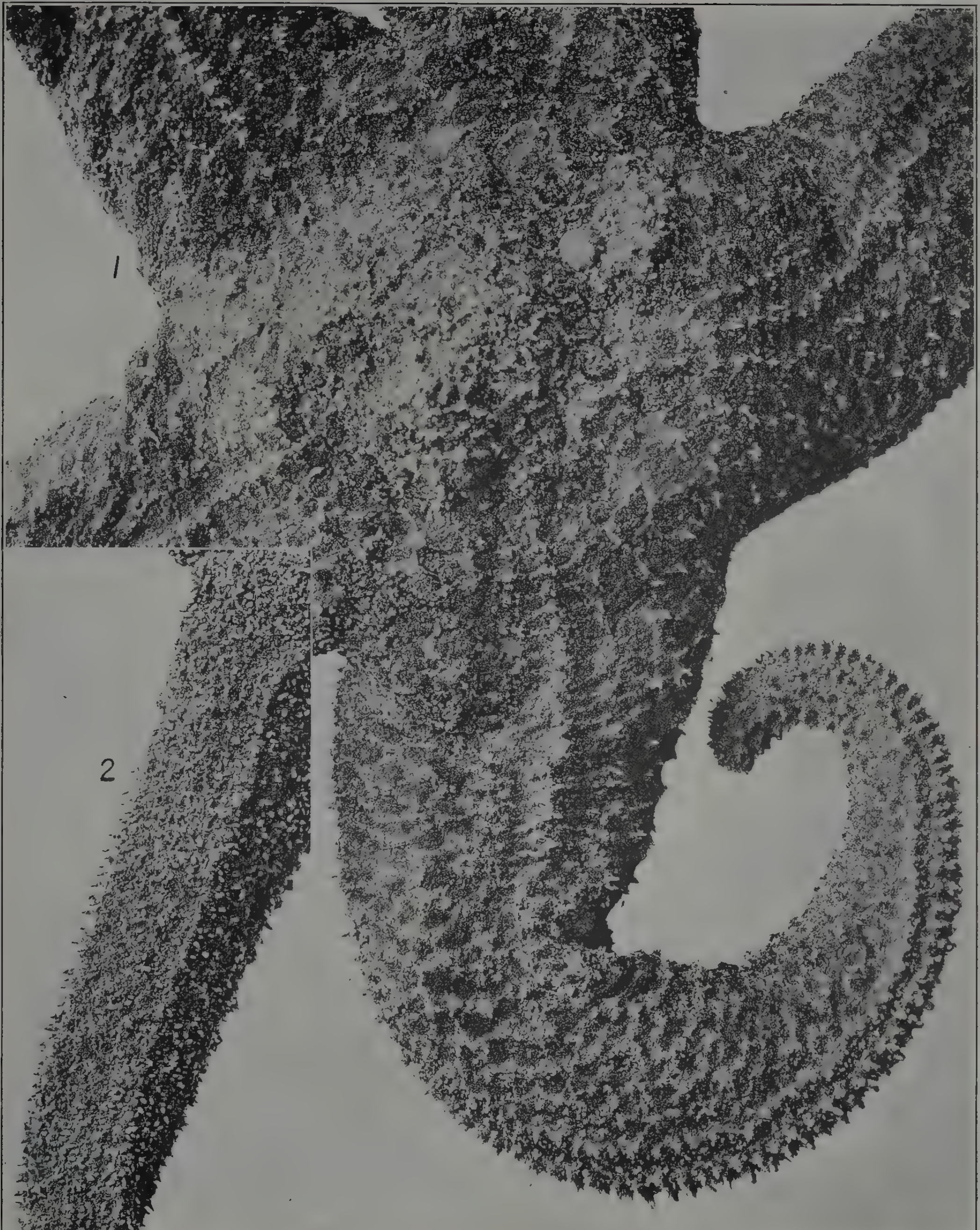
2. Forma *brevispinus*, giant specimen from Lopez Island, San Juan Islands, Wash., ×⅗.

3. Forma *paucispinus*, typical, shallow water, sandy bottom, Monterey Bay, ×1⅓.

PLATE 91

FIGURE 1. *Pisaster brevispinus* forma *brevispinus*. Giant specimen from San Juan Islands, Wash., having much shorter spines than Plate 90, Figure 2, and intermediate with forma *paucispinus*, ×⅘.

2. Forma *paucispinus*, Nanaimo, British Columbia. A subforma with very numerous abactinal straight pedicellariae and few small abactinal spines.



PISASTER BREVISPINUS

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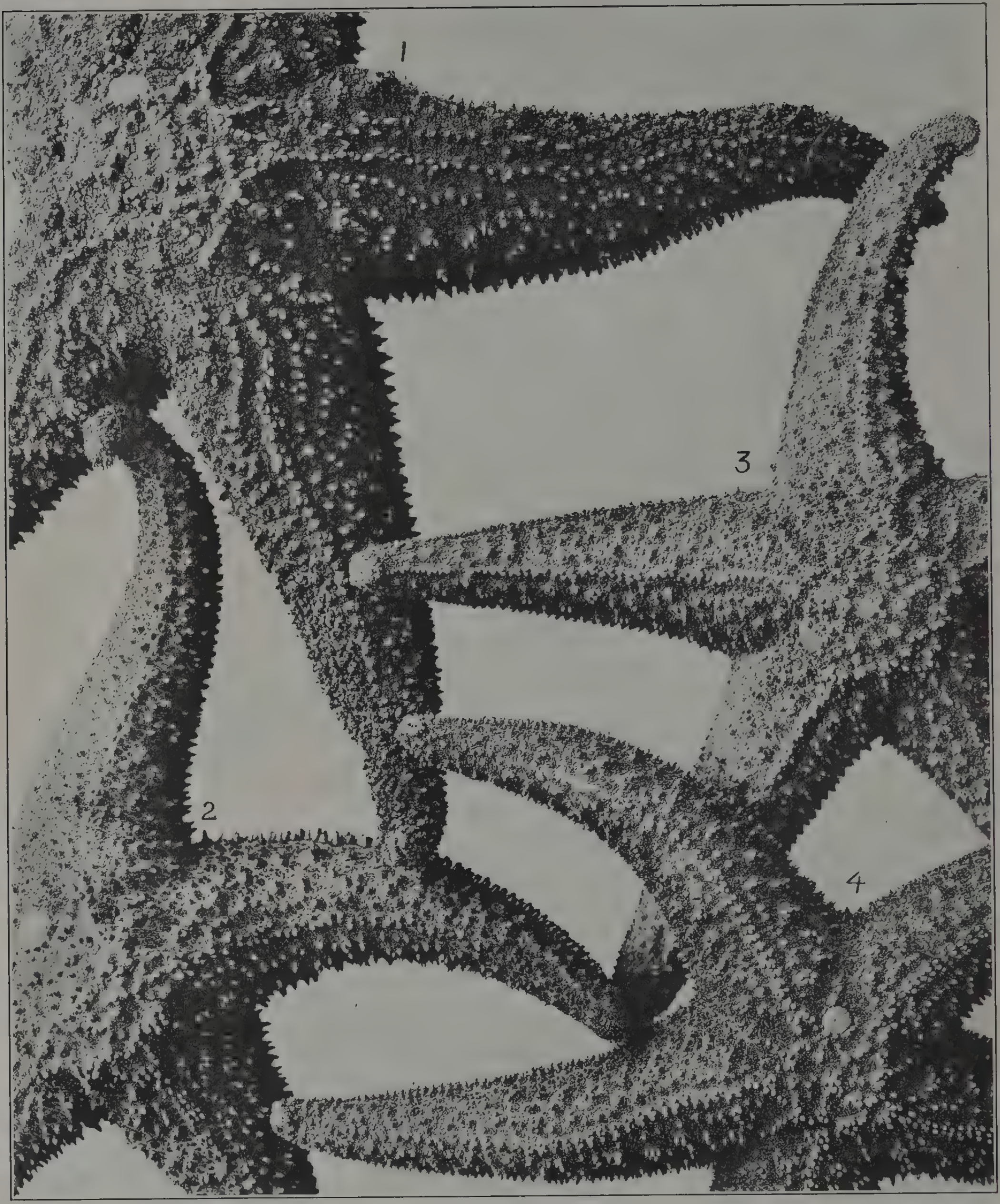


PISASTER BREVISPINUS

FOR EXPLANATION OF PLATE SEE PAGE FACING.

PLATE 92

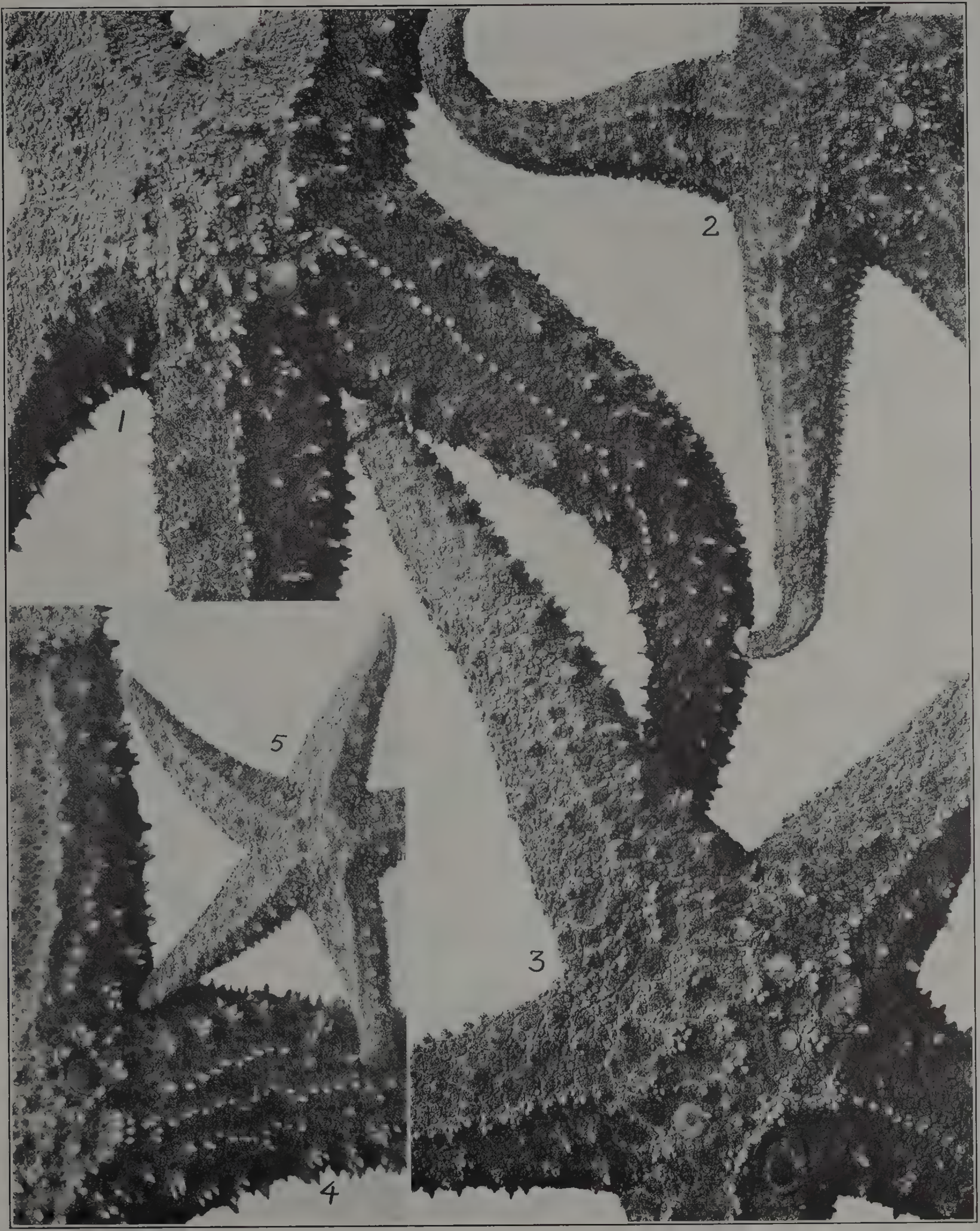
Pisaster brevispinus forma *brevispinus*, ×1¼

FIGURE 1. Monterey Bay, Calif., specimen close to type in general appearance.
2. Station 4487, Monterey Bay.
3. Station 4501, Monterey Bay.
4. Station 4501, typical.

PLATE 93

Pisaster brevispinus

FIGURE 1. Forma *paucispinus*, Monterey Bay, ×1.
2. Same, station 4492, Monterey Bay, unusually few spines, ×1.
3. Same, Barclay Sound, British Columbia. This is Verrill's "*papulosus*," ×1.
4. Forma *brevispinus*, San Francisco Bay. Variety with fewer than typical number of spines, intermediate with *paucispinus*, ×1¼.
5. Forma *paucispinus*, young, station 4563, ×1¼.



PISASTER BREVISPINUS

FOR EXPLANATION OF PLATE SEE PAGE FACING.

INDEX

The following index contains the names of the families, genera, species, subspecies, and formae of Asteroidea which occur in this memoir. Roman type indicates valid names; italic type indicates synonyms, or synonymic combinations. When a species name follows a genus name that is a synonym of another genus name, both the genus and species names of the combination are italicized, although the species may be valid. Heavy-faced type indicates the pages on which descriptions or revisional citations may be found. Names occurring in the explanation of plates have not been indexed.

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